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Tables, one to a page, should be double-spaced throughout and be assigned consecutive Arabic numerals. Collect all figure legends on a separate page. Each illustration should be centered on a single page and be no smaller than final size and no larger than twice final size. The name of the author(s) and figure number, assigned consecutively using Arabic numerals, should be penciled on the back of each figure.

Names for birds should follow the A.O.U. Checklist of North American Birds (7th ed., 1998) or another authoritative source for other regions. Subspecific identification should be cited only when pertinent to the material presented. Metric units should be used for all measurements. Use the 24-hour clock (e.g., 0830 H and 2030 H) and "continental" dating (e.g., 1 January 1999).

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COVER: Black-winged Kite (*Elanus caeruleus*). Painting by Juan Varela (see www.juanvarela.com).

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COPULATION BEHAVIOR OF A POTENTIALLY DOUBLE-BROODED BIRD OF PREY, THE BLACK-WINGED KITE (*ELANUS CAERULEUS*)

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ABSTRACT.—Raptors show high copulation rates when compared to other birds. This fact has been generally attributed to sperm competition. However, copulation rates in raptors tend to be seasonally bimodal, with an early peak outside the female's fertile period that cannot be explained by the sperm competition hypothesis. We studied the copulation behavior of the Black-winged Kite (*Elanus caeruleus*), that, unlike raptors previously studied, may raise two broods consecutively in the same breeding season. The first recorded copulation occurred 44 d prior to the onset of laying and the last one on d 66 after. We observed three seasonal peaks in copulation frequency. The first two peaks (40 and 10 d before egg laying, on average) correspond to the normal pattern in raptors. To explain the first peak, we propose three hypotheses: (1) pair bonding, (2) mate assessment, and (3) territorial signaling. Unfortunately, we have been unable to elaborate further predictions that would distinguish among these three hypotheses. The second peak, during the fertile period, may be attributed to sperm competition. The third peak, previously unreported in raptors, occurred 50 d after the onset of laying, the mean time lag between first and second clutches in the area. These late copulations, which were also performed by pairs that laid one clutch, may reflect the propensity of the species to lay second clutches (we recorded six replacement clutches and five second clutches out of 98 breeding attempts). This third peak of copulations may also have a fertilization function and may be related to sperm competition.

KEY WORDS: *Black-winged Kite*; Elanus caeruleus; *copulation behavior*; *sperm competition*; *territorial signaling*.

COMPORTAMIENTO COPULATORIO DE UNA RAPAZ CON DOBLE NIDADA POTENCIAL: EL ELANIO COMÚN (ELANUS CAERULEUS).

RESUMEN.—Las aves rapaces suelen presentar altas tasas copulatorias cuando se las compara con otras aves. Este hecho ha sido generalmente atribuido a la competencia espermática. Sin embargo, la tasa de cópulas en aves rapaces tiende a presentar un patrón estacional bimodal, con un primer pico antes del periodo en que la hembra es fértil, que no puede ser explicado por esta hipótesis. En este trabajo estudiamos el comportamiento copulatorio del elanio común (*Elanus caeruleus*), que a diferencia de las otras rapaces previamente estudiadas puede sacar adelante dos polladas consecutivas en la misma temporada de cría. La primera cópula se observó 44 días antes del inicio de la puesta y la última 66 días después. Observamos tres picos en la frecuencia copulatoria a lo largo de la temporada de cría. Los primeros dos (alrededor de los días 40 y 10 antes de la puesta) corresponden al patrón observado en otras rapaces. Para explicar el primer pico proponemos que se consideren tres hipótesis: (1) reforzamiento de los lazos de pareja, (2) valoración de la calidad del compañero y (3) señalización del territorio. Desafortunadamente, no hemos podido elaborar predicciones que permitan distinguir entre estas

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tres hipótesis. El segundo pico, durante el periodo fértil de la hembra podría atribuirse a fenómenos de competencia espermática. El tercero, observado por primera vez en rapaces, ocurrió 50 días después del inicio de la puesta, lo que coincide con el intervalo medio entre primeras y segundas puestas en la zona de estudio. Este tercer pico, que también se detectó en aquellas parejas que solo hicieron una puesta, podría reflejar una propensión en esta especie a realizar segundas puestas (encontramos seis puestas de reemplazo y cinco segundas puestas en 98 intentos de cría). Este tercer pico de cópulas estaría probablemente relacionado con la competencia espermática.

[Traducción de los autores]

The copulation behavior of birds has been a popular research topic among behavioral ecologists in the last two decades (e.g., Birkhead et al. 1987, Birkhead and Møller 1992). This interest has been triggered by the observation of widely variable copulation rates between species (i.e., from one to several hundred copulations in a single breeding season), and the realization, through molecular paternity assessment, that extra-pair fertilizations are common in certain species (Petrie and Kempenaers 1998).

Male birds seem to have evolved two strategies to minimize the risk of paternity loss: (1) close mate guarding (Birkhead 1979) and (2) frequent within-pair copulations to dilute the sperm of possible competitors (Birkhead et al. 1987). Most raptor species probably employ the second strategy as males typically provide food to the female throughout the pre-laying period and, therefore, are precluded from guarding their mates effectively (Møller and Birkhead 1992). Raptors show high copulation rates, although the seasonal pattern of copulations in these birds is not consistent with all predictions of the sperm-competition hypothesis. Many raptors show an early peak of copulations 20–65 d before laying, before the females are fertile (Møller 1987, Negro et al. 1992, Villarroel et al. 1998, Mougeot 2000, Negro and Grande 2001), and some species copulate after clutch completion, well into the chick-rearing period (Ellis and Powers 1982, Sodhi 1991, Holthuijzen 1992). In addition, extra-pair copulations, and also extra-pair fertilizations, are infrequent in raptors, and this again calls into question the sperm-competition hypothesis (Negro et al. 1992, 1996, Villarroel et al. 1998, Negro and Grande 2001). There are at least three alternative hypotheses for high copulation rates in raptors. The pair-bonding hypothesis (Newton 1979) states that the members of the pair copulate frequently to maintain or to reinforce the pair bond. Copulations are expected to occur all through the breeding period, but are not necessarily restricted to this period if pair bonds are

maintained through the year. The mate-assessment hypothesis (Tortosa and Redondo 1992, Negro et al. 1996, Villarroel et al. 1998) states that the females may acquire information on male quality through copulations. Assuming that copulations are costly, better males would be able to copulate more often. The territorial signaling hypothesis (Negro and Grande 2001) proposes that raptors signal territory ownership to conspecifics, and possibly to other avian species, by copulating frequently and conspicuously in the defended nesting area early in the breeding season.

The Black-winged Kite (*Elanus caeruleus*; also called the common Black-shouldered Kite in the Old World literature) is a small-sized (ca. 300 g) raptorial bird widely distributed in Africa (Cramp and Simmons 1980). In southern Africa, it breeds continuously, while in other areas of Africa it breeds mostly in the spring and fall (Cramp and Simmons 1980, Brown et al. 1982, Mendelsohn 1983). The species is slowly colonizing southern Europe (Ferrero 1994, Rufino 1994). In Spain, egg-laying peaks in March (Cramp and Simmons 1980, unpubl. data), but in some years some pairs may lay eggs as early as November or as late as July (Ferrero and De Lope 2001).

Our aim with this paper is to describe the copulation behavior and pattern of Black-winged Kites. Contrary to all raptorial species previously studied, the Black-winged Kite may raise two broods in a year (Mendelsohn 1983) and could have evolved a distinct seasonal pattern of copulations (i.e., some copulations are expected to occur after the first clutch).

METHODS

We studied a breeding population of Black-winged Kites in Extremadura, southwestern Spain. The main breeding habitat used by Black-winged Kites in the area consists of fragmented semi-open Mediterranean oak forests (mainly *Quercus rotundifolia*) with an understory of cereal crops (cultivated "dehesas"; Ferrero and Onrubia 1998). The stronghold for the European population (estimated at 1000 breeding pairs [Ferrero 1994]) is located

YEAR	NO. OF PAIRS	TOTAL OBSERVATIONS (hr)
1979	13	123.4
1980	12	20.7
1987	8	46.9
1988	26	53.3
1989	12	126.9
1993	2	32.7
1995	14	44.2
1996	2	8.4
1997	6	19.2
2000	3	11.5

in the dehesas of Extremadura and the neighboring Alentejo in Portugal.

We performed behavioral observations year round on a total of 98 breeding attempts in 79 different nesting territories between 1979 and 2000 (Table 1). We observed six renesting attempts after the first clutch failed to hatch (replacement clutches) and five second clutches. The observations were performed from vantage points at 200–300 m from the nests, using spotting scopes (20–60×) and binoculars (10×). Observers completed 269 observation bouts lasting 10 min to 14 hr (mean observation period: 80 min). Given that it is unlikely to observe copulations during very short observation periods, only those bouts more than 20 min long were used to calculate copulation rate and to plot the seasonal pattern of copulations. We were unable to distinguish between successful and unsuccessful copulations, and therefore we defined a copulation as occurring when a male mounted a female. Copulations as well as other distinct behaviors, including prey transfers among pair members, chasing to intruders, aerial displays, and delivery of nest material, were recorded and timed.

Black-winged Kites in this study were not individually marked. This limitation may have resulted in the detection of intruders, and thus, observation of extra-pair copulations. Nonetheless, any intrusions by conspecifics during observations would be easily detectable, as home ranges of kites are relatively small (2–4 km², Mendelsohn 1983, Bustamante 1993, J. Ferrero unpubl. data), tree cover in the dehesas is sparse (3–9 trees/ha), and territorial birds may be observed continuously. In addition, Black-winged Kites are strongly territorial and intruders are evicted from the nesting areas (Mendelsohn 1983, see Results). The absence of marks may also have caused pseudoreplication due to the inclusion of data from the same pairs observed for more than one year. However, given the length of the study period (21 yr), and even considering that 13 territories were monitored twice or even three times, the long time lag between two consecutive observations in the same territory (5.8 ± 4.8 yr, on average), it is unlikely these territories were occupied by the same individuals. The remaining 65 territories were

sampled once. Therefore, we believe the incidence of pseudoreplication is minimal in our analysis.

We analyzed the daily variation in copulation rates during the fertile period. In previous studies on copulation behavior of raptors, the fertile period has been assumed to start around 12 d prior to laying (Bird and Buckland 1976, Negro et al. 1992, Donázar et al. 1994, Mougeot 2000). With no data available for the Black-winged Kite, we have conservatively assumed that the fertile period started 15 d before the onset of laying and ended around 10 d after when the clutch was completed (4–5 eggs layed with an interval of 2 d between consecutive eggs in the clutch [Cramp and Simmons 1980]). For analytical purposes and given that Black-winged Kites present activity peaks at dawn and dusk (Cramp and Simmons 1980), we divided daytime into three periods: (1) from sunrise to 3 hr later, (2) midday hours (of variable duration owing to photoperiodic variation throughout the copulatory period), and (3) from 3 hr before sunset to sunset. As the copulation rate within the different observation bouts followed a Poisson distribution, we fitted a Generalized Linear Model (GLM) with Poisson errors to test for differences among the three defined daily periods.

To analyze seasonal variation, days of observation were grouped into 5-d intervals relative to the estimated onset of laying (considered as day zero), and thus, independently of the period of the year in which each pair started to breed.

To calculate hatching dates the 8th primary feather of the oldest chick of three different broods, whose hatching date was precisely known, was measured twice a week through the chicks' growing period until they were about to fledge. Using these data a linear regression of the length of the 8th primary feather on age (in days) was calculated (age = 0.1837 primary + 10.277, $r^2 = 0.9852$, $P < 0.0001$). This regression line was subsequently used to estimate hatching dates for the remaining chicks in the study. Laying date was then estimated from hatching date assuming a 31 d incubation period (del Hoyo et al 1994). Data from nests that failed early, for which we did not know the laying date, were excluded from analysis. Copulations during second breeding attempts, for which observations were limited, were not considered to profile the species' seasonal-copulation pattern.

RESULTS

Copulation Behavior. Each pair of Black-winged Kites usually copulated at 3–4 exposed perching sites in the nesting territory (not further than 150 m from the nest). These perching sites tended to be high and leafless branches at the top of a tree, which along with the bold coloration of the birds (white breast and belly, bluish grey upperparts) and their noisy vocalizations made copulations very conspicuous. No copulations were recorded at the nest. Copulation duration averaged 11.01 ± 0.45 sec ($\bar{x} \pm$ SE, $N = 75$).

On 161 instances, we recorded the behavior of the kites immediately before copulation took place. For 55 copulations (34.2%) we did not ob-
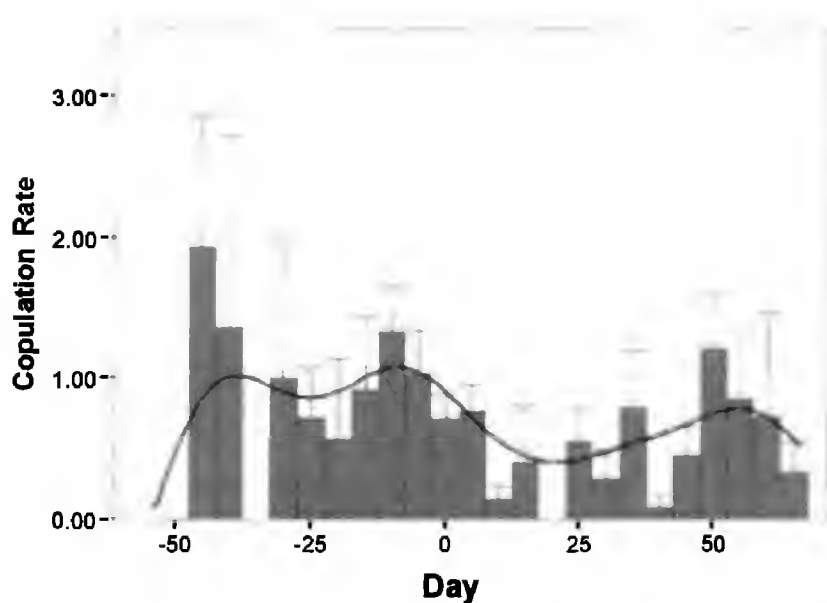
Figure 1. Mean ± SE frequency of copulation/hr of the Black-winged Kite related to the onset of laying (d 0). The line was adjusted with a normal kernel smoother.

serve any prior social behavior among mates. In some cases, two or more characteristic behaviors preceded copulation. The male transferring prey to his mate preceded 32 copulations (19.8%). On those occasions, the male waited until the female finished her meal, then flew directly onto her back and copulated. Thirty-one copulations (19.2%) were preceded by the delivery of sticks to the nest by one member of the pair. On 26 occasions (16.1%) copulations occurred shortly after aggressive encounters had taken place with intruding birds, mainly Common Buzzards (*Buteo buteo*) and Common Ravens (*Corvus corax*), which were chased away from the breeding area. Intruding Black-winged Kites were observed in 4.8% of the observation periods (13 out of 269 observation bouts). As with the other bird species, intruding kites were invariably expelled by one or both members of the pair. Only two of these intrusions by conspecifics were immediately followed by copulation of the resident pair.

Frequency and Timing of Copulations. A total of 216 copulations were observed in 487.3 hr of observation. The first recorded copulation occurred 44 d prior to the onset of laying and the last one on d 66 after the onset of laying. The maximum number of copulations seen during a single observation bout was nine in 4 hr, which occurred 12 d prior to laying a second clutch.

Using six pairs for which we have observational data on more than 10 different days, and considering daytime periods of 12 hr and a copulation period of 110 d (Fig. 1) we estimated 600.6 ± 166.2 copulations/female for the whole breeding

season and 354.9 ± 98.2 for the first breeding attempt (65 d).

Combining data from the different pairs under investigation, but excluding those that laid a second clutch (see Methods), a trimodal pattern emerged in daily copulation rates through the breeding season (Fig. 1). There was a first peak around d −40 and a second peak at d −10. Kites started to copulate again around 25 d after laying, resulting in a third copulation peak around d 50, almost coinciding with the mean dates of replacement clutches (53.83 ± 4.04 d after laying date of the first clutch, N = 6) and close to the mean date for second breeding attempts (second laying date, 62 ± 3.76 d after laying date of the first clutch, N = 4). We failed to find differences in copulation rates between the three defined daily periods (i.e., 3 hr post sunrise, midday and 3 hr to sunset), as the change in deviance of the GLM was not significant (P = 0.36). No copulations were detected in twilight, despite the fact that the kites were observed hunting frequently at these times.

DISCUSSION

Patterns of Copulation. Copulations in the Black-winged Kite were conspicuous, and thus, easily detectable. Copulations were distributed throughout the daytime, and were not necessarily associated to other social behaviors such as mate feeding. The two peaks in copulation frequency before and during the presumed fertile period of female Black-winged Kite have previously been observed in other raptors (Møller 1987, Negro et al. 1992, Pandolfi et al. 1998, Villarroel et al. 1998, Mougeot 2000). The third peak, at day +50, is reported for the first time in raptors, although it was anticipated due to the relative frequency of second clutches among Black-winged Kites. Considering only the copulations performed during a single breeding attempt (presumably the first one in the majority of pairs that we studied), copulation rates were high and in the range found in other diurnal raptors (see references above, also Balgooyen 1976, Rosenfield et al. 1991, Korpimäki et al. 1996). Our estimate for the Black-winged Kite (around 5.5 copulations/d) is similar to that reported by Van Der Merwe (1980) for a pair in South Africa (7 copulations/d in a 15-d period during nest building).

As we already discussed (see Introduction), the first peak in copulation frequency around 40 d prior to laying is unlikely related to fertilization, as it

probably occurs well before the female's fertile period. Alternative hypotheses, such as mate-assessment or strength of the pair bond hypotheses predict higher copulation rates at the time of pair formation or pair reunion, but are difficult to test. The territory-signaling hypothesis predicts frequent and conspicuous copulations when a pair establishes a breeding territory (Negro and Grande 2001). In the Black-winged Kite, copulations are indeed very frequent and almost always occur on conspicuous perches. The frequency of copulations immediately preceded by agonistic encounters with other bird species or conspecifics is not negligible (16%). Our data seem to support the territory-signaling hypothesis as a possible explanation for the early peak in copulations as suggested for most diurnal raptors (Negro and Grande 2001), but we cannot discard either the pair-bond or the mate-assessment hypotheses.

The second peak in copulation frequency, at the beginning of the female's fertile period, may be related to sperm competition pressures. However, some aspects of the kite's behavior seem to indicate low levels of sperm competition during this second peak. First, as in other frequently-copulating birds (Tortosa and Redondo 1992, Birkhead and Møller 1993, Bertran and Margalida 1999), the copulation rate decreased from beginning to end of the fertile period. In the context of sperm competition, copulation rates should be highest at the onset of laying (Birkhead 1988, Birkhead and Møller 1992, but see Birkhead and Møller 1993). Two intrusions of Black-winged Kites followed by copulation of the resident pair occurred during the fertile period. However, intrusions by conspecifics do not seem to be frequent, at least in our study area. Bustamante (1993) found only six intrusions in 146 hr of observation (0.04 intrusions/hr), and we found just 13 in 487 hr (0.03 intrusions/hr), which is similar to that found in the Merlin (*Falco columbarius*, 0.02–0.05 intrusions/hr, Sodhi 1991). Mougeot (2000) reported higher frequencies of intrusions for the Red Kite (*Milvus milvus*, 0.7–4 intrusions/hr).

Copulations After the First Nesting Attempt: Renesting, Second Clutches or Sequential Polyandry? The most remarkable finding of our study is the existence of a third peak in copulation frequency later in the breeding season, close to the fledging time of the young produced in the first breeding attempt. In some raptors, copulations cease at the end of laying or close to it (Newton 1986, Birkhead

and Lessells 1988, Negro et al. 1992, Mougeot 2000). In other species the occurrence of copulations during incubation or even during the nestling period are not uncommon (Ellis and Powers 1982, Holthuijzen 1992, Donázar et al. 1994, Pandolfi et al. 1998). Nonetheless, we know of no other raptor species in which late copulations reached similar rates to those of the pre-laying period, as we found in this study. Copulations after clutch completion are suggested to be a preventive behavior to speed up a replacement clutch if the first one is lost (Birkhead et al. 1987). But renesting attempts are scarce among raptors, especially in larger ones (Newton 1979, Mundy et al. 1992, Martínez et al. 1998). Second breeding attempts are even rarer, but do occur in some species (Newton 1979, Toland 1985). In the Iberian Peninsula only the Eurasian Kestrel (*Falco tinnunculus*) has been observed raising a second brood in the same year (Sánchez 1990, Fargallo et al. 1996). When conditions permit, the Black-winged Kite may breed two or more times in a year (Mendelsohn 1983). Appropriate conditions do not seem to be common in Spain but they do occur, as we observed five second-breeding attempts. In small birds, such as passerines, both replacement clutches and multiple breeding attemps are common (e.g., Møller 1985), and therefore, copulations are expected in these species after the first breeding attempt. However, we have found no analysis on the seasonal pattern of copulations in multiple-brooded species.

The coincidence of the third peak in copulation rates with the dates of replacement or double clutches may be an adaptation related to the tendency of the Black-winged Kite to initiate a second breeding attempt, which they may abort just before laying if food conditions are not adequate. Although data on female's fertility in this period are lacking, it may be argued that these copulations occur in a fertilization context and sperm competition might play a role.

The unusual early laying dates that we recorded in some years (i.e., November or December, Ferrero and De Lope 2001) seem to indicate that independently of seasonal photoperiodic and climatic variation of the temperate zones, Black-winged Kites may try to breed if other factors (most probably food abundance) are favorable.

Bustamante (1993), in a study carried out in the same area, found that two radiotagged adult females had left the nest well before the nestlings became independant, whereas the male fed the

young until they dispersed from the territory. In three other pairs (with unmarked birds) this author was unable to conclude if both adult birds remained in the territory or not. We have also found some evidence of only one adult remaining until the young fledge, but this does not exclude the possibility that other pairs remain together and initiate a second breeding attempt. In fact, we did not find any evidence of mate switching (temporal disappearance of one of the pair members) in the six renesting attempts, and at least in one of the second breeding attempts both members of the pair fed the young of the first brood while copulating and constructing the second nest in a neighboring tree. Unfortunately, as our birds were not marked, we cannot conclude if renesting or second breeding attempts (and therefore the third copulation peak) are performed by the same mates, or as occurs in South Africa (and in Australia by the Letter-winged Kite, *Elanus scriptus*), the female involved in the male's second attempt is a different individual (Mendelsohn 1983, Marchant and Higgins 1993).

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MORTALITY, MORBIDITY, AND LEAD POISONING OF EAGLES IN WESTERN CANADA, 1986–98

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ABSTRACT.—Between 1986 and 1998, we investigated causes of mortality and morbidity, and assessed lead (Pb) contamination in Bald (*Haliaeetus leucocephalus*) and Golden eagles (*Aquila chrysaetos*) in western Canada. The most common diagnoses were trauma (13.0%), electrocution (11.5%), pesticide poisoning (7.6%), gunshot wounds (7.3%), and Pb poisoning (6.4%). It was not possible to determine the cause of mortality or morbidity in 29% of the 546 eagles. Excluding undetermined cases and those with an unknown collection date, toxicoses accounted for 40% of the diagnoses in the prairie provinces, but only 19% of those in British Columbia ($P < 0.001$). Ten percent of eagles ($N = 372$) had tissue Pb levels consistent with Pb poisoning and 5% had elevated, but non-lethal Pb levels. Age class and species differed significantly among eagles with either background or high (Pb-poisoned and elevated Pb) Pb levels ($P \leq 0.01$). When data from both species were combined, high Pb levels were detected in 19.5% of adult and subadult eagles ($N = 220$) but only 7% of immature eagles ($N = 128$). Twenty-eight percent of Golden Eagles ($N = 39$) but only 13% of Bald Eagles ($N = 333$) had high Pb levels. Proportions of eagles with high and background Pb levels were not different based on the level of waterfowl hunting near the locations of collection ($P \geq 0.48$). Golden Eagles with high tissue Pb concentrations tended to be found more often during or soon after the fall hunting season than eagles with background Pb concentrations ($P = 0.08$). The greater incidence of high Pb in Golden Eagles compared to Bald Eagles and the lack of relationship with waterfowl hunting intensity suggest that waterfowl is not the primary source of Pb for eagles in western Canada.

KEY WORDS: *Bald Eagle;* Haliaeetus leucocephalus; *Golden Eagle;* Aquila chrysaetos; *lead; lead poisoning; pesticide poisoning; toxicity.*

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MORTALIDAD, MORBILIDAD, E INTOXICACIÓN POR PLOMO DE ÁGUILAS EN EL OESTE DE CANADÁ, 1986–98

RESUMEN.—Entre 1986 y 1998, investigamos las causas de mortalidad y morbilidad, y evaluamos la contaminación por plomo (Pb) en águilas calvas (*Haliaeetus leucocephalus*) y águilas doradas (*Aquila chrysaetos*) en el oeste de Canadá. El diagnostico mas común fue trauma (13.0%), electrocución (11.5%), envenenamiento por pesticidas (7.6%), heridas por arma de fuego (7.3%), y envenenamiento con plomo Pb (6.4%). No fue posible determinar la causa de mortalidad o morbilidad en 29% de las 546 águilas. Excluyendo los casos indeterminados, la toxicosis dio cuenta de 40% de los diagnósticos en las provincias de la pradera, pero únicamente en 19% de los mismos para British Columbia (*P* < 0.001). Diez por ciento de las águilas (N = 372) tuvo niveles de Pb en los tejidos consistentes con el envenenamiento por Pb y 5% tuvieron niveles elevados pero no letales de plomo. Las clases de edad y las especies difirieron significativamente tanto entre águilas con antecedentes como en aquellas con altos niveles de plomo (envenenadas o con Pb elevado) (*P* ≤ 0.01). Cuando los datos de ambas especies se combinaron, los altos niveles de plomo se detectaron en 19.5% de las águilas adultas y subadultas (*N* = 220) y únicamente en 7% de las águilas inmaduras (*N* = 128). Veintiocho por ciento de las águilas doradas (*N* = 39) y únicamente 13% de las águilas calvas (*N* = 333) tuvieron altos niveles de plomo. Las proporciones de águilas con antecedentes y altos niveles de plomo no difirieron con base en el nivel de aves acuáticas cazadas cerca de las localidades de colección (*P* ≥ 0.48). Las águilas doradas con alta concentración de plomo en los tejidos se hallaron más frecuentemente durante o un poco después de la estación de caza de otoño que las águilas con antecedentes de concentraciones de plomo (*P* = 0.08). La mayor incidencia de altos niveles de plomo en águilas doradas que en águilas calvas y la carencia de interrelaciones con la intensidad de caza de aves acuáticas, sugiere que las aves acuáticas no son la fuente primaria de plomo para las águilas del occidente de Canadá.

[Traducción de César Márquez]

Lead (Pb) poisoning in waterfowl has long been recognized as an environmental problem in North America (Bellrose 1959). More recently, it has been documented in other avian species (Locke and Friend 1992). Since the 1960s, Pb poisoning has accounted for ca. 1–15% of recorded mortality in Bald Eagles (*Haliaeetus leucocephalus*) and other raptors (Mulhern et al. 1970, Pattee and Hennes 1983, U.S. Fish and Wildlife Service 1986, Pain and Amiard-Triquet 1993, Wayland and Bollinger 1999). The primary source of Pb in poisoned raptors is assumed to be shot or bullets used by hunters (Pattee and Hennes 1983, Scheuhammer and Norris 1995, Kendall et al. 1996). Raptors are exposed to Pb by consuming prey containing Pb shot or bullet fragments (Pattee and Hennes 1983, Pattee et al. 1990, Pain et al. 1993, Harmata and Restani 1995, Pain et al. 1997, Mateo et al. 1999).

While there is a strong association between the ingestion of Pb ammunition from prey tissues and Pb poisoning in raptors, the importance of Pb shot in waterfowl as the main contributing factor is less certain. Pattee and Hennes (1983) hypothesized that Pb shot in waterfowl was the major source of Pb exposure in Bald Eagles; however, Pb ammunition embedded in the tissues of other prey animals may also be important (Kramer and Redig 1997). In the case of Golden Eagles (*Aquila chry-saetos*), upland game animals are believed to be a more important source of Pb shot than are waterfowl (Pattee et al. 1990). It is important to distinguish between waterfowl and other prey as the main source of Pb exposure, because Pb ammunition has been banned in Canada since 1999 for hunting waterfowl, but not for hunting other types of game.

We examined causes of death, illness, and injury in Bald and Golden eagles from western Canada to evaluate Pb poisoning as a cause of mortality and morbidity. In addition, we assessed whether sublethal concentrations of Pb were associated with toxicosis, physical injury, or disease, as sublethal exposure to Pb can predispose birds to other causes of death (Burger 1995). We compared the prevalence of high Pb levels among different age classes of eagles because population levels of some raptors are linked to the survival of adult, reproducing birds (Grier 1980, Newton 1988). To assess whether Pb ammunition is the probable, primary source of Pb exposure in eagles in western Canada, we determined whether the prevalence of elevated Pb levels was highest during and soon after the fall hunting season. Moreover, we examined elevated Pb levels in the context of waterfowl hunting intensity and interspecific dietary differences to test the hypothesis that consumption of waterfowl is a major source of Pb exposure in eagles.

METHODS

Sample Collection. From 1986–98, provincial wildlife agencies and raptor rehabilitation organizations in Manitoba, Saskatchewan, Alberta, and British Columbia (BC) received dead, sick, and injured Bald and Golden eagles. The sex of birds in rehabilitation centers was determined based on morphometric measurements (Bortolotti 1984a, 1984b), and all dead birds were sexed during necropsy. Plumage characteristics were used to estimate age (Bortolotti 1984b, McCollough 1989), and eagles were designated as immature, subadult, or adult. Birds in rehabilitation centers were diagnosed by the staff of these facilities, not necessarily a veterinarian. Dead eagles were frozen until necropsies could be performed by veterinary pathologists.

Blood samples were drawn from live eagles in rehabilitation centers, placed in vials prewashed with nitric acid, and frozen at −20°C until subsequent Pb analysis. In addition, plasma samples from 96 birds in rehabilitation centers in BC were analyzed for cholinesterase activity. Kidneys and livers were removed during necropsy and refrozen at −20°C in glassware prewashed with nitric acid or acetone/hexane. These tissue samples were sent to the National Wildlife Research Centre in Hull, Québec, for Pb analysis.

Brain tissue was collected and frozen for analysis of cholinesterase activity when organophosphate (OP) or carbamate pesticide poisoning was suspected based on evidence found in the field or at the time of necropsy. Such evidence included the presence of insecticide-laced bait or other dead animals at the field site, and copious quantities of meat in the gastrointestinal tract of an eagle carcass in good condition. Diagnoses of pesticide poisoning were made based on this evidence, residue analysis, and cholinesterase activity ≤60% of normal levels for that species (Greig-Smith 1991). Stomach and crop contents of 23 eagles that were suspected to have been poisoned were analyzed for residues of OP and carbamate pesticides known to be used widely in the study area (Elliott et al. 1996, 1997, T. Bollinger unpubl. data). Brain cholinesterase activity was determined in 19% of eagles collected from BC and in 22% of those from the prairies, using methods similar to those described by Martin et al. (1981) and Hill and Fleming (1982).

Lead Analysis. Blood samples (100 µl) were pipetted into 1500 µl Eppendorf micro-centrifuge tubes containing 400 µl of a 0.2% $NH_4H_2PO_4$ plus 0.5% Triton X-100 solution. Each tube was capped and shaken for 10 sec. Pb was determined by graphite furnace atomic absorption spectrometry (GFAAS) using a Perkin-Elmer 3030b spectrophotometer equipped with a HGA-300 graphite furnace and an AS-40 autosampler, according to methods described by Fernandez and Hilligoss (1981). Blood Pb values are expressed as µg Pb/ml blood. Blank solutions were analyzed to verify that Pb was below detection limits. Sample detection limits ranged from 0.005–0.025 µg/ml. Recoveries of spiked samples ranged from 87–110% and averaged 97%. Coefficients of variation of duplicate and triplicate analyses ranged from 7–11% and averaged 9%.

Aliquots of liver and kidney samples were weighed to determine wet weights; placed in plastic, nitric acid-washed test tubes; freeze-dried; and their dry weights recorded. Samples were digested in a solution of deionized water and 70% nitric acid, at a concentration of 0.5 ml solution per 0.1 g dry weight of sample. Pb levels in liver and kidney tissues were expressed on a dry weight basis. Pb was analyzed by flame-atomic absorption spectrometry (AAS) using an atom concentrator tube (ACT-80). The detection limit ranged from 1.0–2.0 µg/g dry weight. Samples in which Pb was not detected using flame-AAS were analyzed by GFAAS as described above. Detection limits using the GFAAS ranged from 0.3–1.0 µg/g dry weight. Recovery of Pb from spiked samples and standard reference materials ranged from 68–118% and averaged 93%. Coefficients of variation ranged from 0–19% and averaged 6%.

Pb concentrations greater than 1.0 µg/ml blood, 30 µg/g dry weight liver, or 20 µg/g dry weight kidney were considered to be diagnostic of Pb poisoning, while concentrations greater than 0.2 µg/ml blood or 6 µg/g dry weight liver or kidney indicated elevated Pb exposure (Pattee et al. 1981, Redig et al. 1984, Reichel et al. 1984, Pain et al. 1994, Franson 1996). When liver and kidney Pb levels were reported in the literature on a wet-weight basis, they were converted to dry weight values using mean tissue moisture values determined in this study to be 76.5% for eagle kidney and 71% for eagle liver. For certain analyses, the Pb-poisoned and elevated Pb categories were combined into a single high Pb group. Pb levels lower than those values stated above were considered to be due to background exposure.

Data Analysis. Causes of death or morbidity were classified into three categories: (1) physical injury, including drowning, electrocution, collision, gunshot, and other trauma; (2) disease and debilitation, including avian cholera, other diseases, emaciation, and degeneration; (3) toxicosis, including pesticide and suspected pesticide poisoning, Pb poisoning, and other poisonings (mercury and strychnine). Two-way contingency table analysis was used to test the relationship between cause of death or morbidity and species. Data from both species were combined in subsequent analyses because no difference was detected among proportions of Bald and Golden eagles within the three diagnostic categories ($\chi^2 = 0.7, P = 0.70$, $N = 388$). This was followed by log-linear analysis using the maximum-likelihood technique (PROC CATMOD, SAS Institute 1988) to examine relationships among cause of death or morbidity, region (prairie provinces and BC), and time period. The two time periods examined were May–October, which represented the breeding season, and November–April, which represented autumn migration, wintering, and spring migration. The latter time period included months during and soon after the fall hunting season, which occurs from September–December. The log-linear model included all main effects as well as two-way interactions that included cause of death or morbidity. Separate analysis of the relationship among species and cause of death or morbidity was required because there were too few Golden Eagles ($N = 39$) to include in the multi-way log linear table.

We used analysis of variance of rank-transformed kidney Pb level data to evaluate if Pb exposure at background and sublethal levels predisposed eagles to particular causes of death or morbidity. We used logistic regression with maximum likelihood estimation (PROC CATMOD) to determine if Pb levels were related to age

class, date of recovery, waterfowl hunting intensity, or species. Only main effects were included in the model. In addition, we used two-sample Wilcoxon tests to examine relationships between Pb levels and time of year of recovery, relative to the fall hunting season (September–December). Throughout this study, P values less than 0.05 were considered significant.

We examined the geographic association among Pb levels in eagles and waterfowl hunting intensity. To do so, we used harvest survey data (Canadian Wildlife Service unpubl. data) from 1990–95 to estimate mean number of waterfowl-hunting-days/year. Waterfowl-hunting-days data were provided as point estimates that represented 30-min by 30-min blocks of land. Geostatistics, a point surface interpolation technique, was used to derive estimates of waterfowl hunting activity across the study area (GS+® version 3.11.7, Gamma Design 1999). Geostatistics is an acceptable method for estimating data values for locations that were not sampled directly, by examining data from locations that were sampled. A model of spatial correlation was established and used to interpolate data values at the unknown locations.

The first step of geostatistics is to calculate the sample semivariance and use that to estimate the shape of a curve that represents the semivariance as a function of distance. The second step is to use the estimated semivariance function to determine the weights needed to define the contribution of each sampled point to the interpolation. Sample points close to the point for which an estimated value is to be generated contribute the most to the interpolation. The waterfowl-hunting-days data fit an exponential model ($R^2 = 0.98$ and residual sums of squares = 0.052), indicating that the variability in hunting activity among locations was a function of distance. Thus, spatial interpolation of the data was appropriate, and waterfowl-hunting-days were interpolated at a resolution of 10 km × 10 km across the study area. Interpolation of the waterfowl-hunting-days data for a specific location was done using nearest-neighbor values weighted by distance and the degree of autocorrelation present for that distance. A maximum of 16 nearest neighbors lying within a 30-km radius of the specific location was used in the interpolations. Low intensity waterfowl hunting areas were designated as those with fewer than 1000 hunting-days/year, and accounted for 87% of the 100 km^2 hunting areas. Hunting activity on high intensity waterfowl hunting areas ranged from 1000–11 178 hunting-days per year.

Eagles with high Pb levels that had been shot ($N = 5$) were excluded from statistical analyses of Pb contamination because the elevated Pb levels in their tissues may have resulted from embedded Pb shot fragments rather than metabolic uptake of Pb (Wayland et al. 1999). Samples from eagles that had been in rehabilitation centers for >3 wk were not used in analyses because Pb concentrations normally decline to background levels within that time period (Reiser and Temple 1981). Similarly, eagles that received chelating agents to bind Pb were not used in analyses.

RESULTS

Causes of Death, Injury, or Illness. Cause of death, injury, or illness could not be determined

Table 1. Final diagnoses for 546 dead and debilitated Bald and Golden eagles in western Canada, 1986–98

DIAGNOSIS	BRITISH COLUMBIA BALD EAGLE	BRITISH COLUMBIA GOLDEN EAGLE	PRAIRIE PROVINCES BALD EAGLE	PRAIRIE PROVINCES GOLDEN EAGLE	TOTAL
Degeneration or emaciation	21	3	5	3	32
Avian cholera	0	0	6	0	6
Other infectious disease	14	0	8	2	24
Pesticide poisoning	20	0	19	3	42
Lead poisoning	19	1	11	4	35
Other poisoning	2	0	3	0	5
Suspected poisoning[a]	4	0	12	2	18
Collision	34	0	1	2	37
Drowning	15	0	0	0	15
Electrocution	50	0	4	9	63
Gunshot	25	0	14	1	40
Other trauma[b]	33	1	29	8	71
Undetermined	123	4	22	9	158

[a] Poisoning suspected because of additional evidence.
[b] Category includes wing injuries, attacks by other eagles, leg injuries, trap-related injuries, unknown origin, soaked feathers, internal injuries, asphyxiation, spinal injuries, fall from nest, and exhaustion.

for 158 of 546 eagles that were examined. Thirteen percent of eagles were diagnosed with trauma other than electrocution, drowning, collisions, or gunshot wounds; 11.5% were electrocuted; 7.6% were pesticide-poisoned; 7.3% were shot; 6.4% were Pb-poisoned, and 25% died or were debilitated by other causes (Table 1). Eagles poisoned by OP or carbamate insecticides had mean ±SD brain cholinesterase activity of 8.4 ± 6.5 μmol/min/g ($N = 22$). The corresponding values for eagles diagnosed with other or undetermined causes of death ($N = 7$) were 17.5 ± 2.8 μmol/min/g. Excluding the cases with undetermined cause of death or date of collection, proportional differences in causes of death or morbidity of eagles ($N = 370$) were related to region where they were found ($P < 0.001$; Fig. 1), but not to time of year ($P = 0.09$). Poisonings and suspected poisonings accounted for 40% of diagnoses of eagles from the prairie provinces, but only 19% of those from BC. In contrast, 45% of eagles from the prairies and 66% of those from BC were injured.

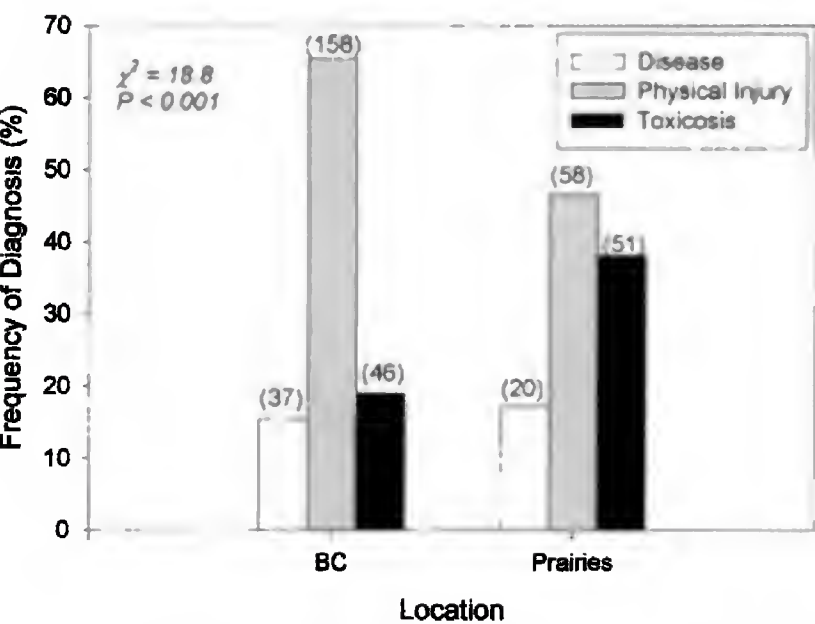**Lead Exposure and Poisoning.** Pb levels were de-

Figure 1. Percent frequency of three categories of diagnosis of death and morbidity, according to the region where eagles were found. Unknown causes of death and morbidity have been excluded. Utilization of a log-linear model showed that cause of death or morbidity was influenced by region. Numbers in parentheses indicate sample sizes.

termined in kidney, liver, or blood samples from 372 eagles (Table 2). Most eagles (85%) had background levels of Pb and 15% had high Pb levels in their tissues. The high Pb group included eagles with Pb levels consistent with poisoning (10%) and those with elevated Pb levels (5%).

Bald Eagles with toxicoses other than Pb poisoning had higher Pb levels than those diagnosed with various physical injuries, disease, or debilitation ($P = 0.037$). For Bald Eagles, median values for kidney lead levels in three categories of diagnosis were as follows: toxicoses other than lead poisoning—1.09 µg/g ($N = 29$); physical injuries—0.27 µg/g ($N = 139$); and disease and debilitation—0.26 µg/g ($N = 37$). There was no difference in kidney Pb levels among groups of Golden Eagles ($P = 0.614$).

Median values for kidney Pb levels in Golden Eagles with toxicoses other than Pb poisoning ($N = 4$), physical injuries ($N = 16$), and diseases or debilitation ($N = 6$), were 0.77, 0.74, and 1.27 µg/g, respectively.

Age class and species differentiated between eagles with background or high Pb levels ($P \leq 0.01$). Adult and subadult eagles had a higher percentage with high Pb levels than did immature eagles. This difference was evident for Bald Eagles ($P = 0.005$) and when data from both species were combined ($P = 0.002$). High Pb levels were detected in 17.6% of adult and subadult Bald Eagles, but in only 5.9% of immature Bald Eagles. When data from both species were combined, 19.5% of adult and subadult eagles, and 7.0% of immature eagles had high Pb levels. In Golden Eagles, the percent of adult and subadult birds with high Pb (36.3%) was not different from the percent of immature eagles with high Pb (20.0%, $P = 0.58$). In comparison with Bald Eagles, a higher percentage of Golden Eagles had high Pb levels. The percent of Bald Eagles with high Pb levels in the immature and subadult/adult age classes were 5.9% and 17.6%, respectively. The percent of Golden Eagles with high Pb levels in these age classes were 20.0% and 36.3%, respectively.

Date of recovery and waterfowl hunting intensity failed to provide additional discrimination between the background and high Pb groups ($P \geq 0.19$). However, Golden Eagles with high Pb levels tended to be found during or soon after the fall hunting season (Fig. 2), while those with background Pb levels were more often found several months later. This seasonal difference in date of recovery approached significance (Wilcoxon two-sample test, $P = 0.08$). Date of recovery of Bald Eagles, as related to hunting season, did not differ

Table 2. Pb levels in tissues from 372 immature, subadult, adult, and unknown age Bald and Golden eagles collected from western Canada, 1986–98.

	BALD EAGLE			GOLDEN EAGLE			
		SUBADULT AND			SUBADULT AND		
PB LEVEL	IMMATURE	ADULT	UNKNOWN	IMMATURE	ADULT	UNKNOWN	TOTAL
Background[a]	111	163	15	8	14	6	317
Elevated[b]	1	11	1	1	4	0	18
Poisoned[c]	6	24	1	1	4	1	37

[a] Pb <6 µg/g dry weight kidney or liver; <0.2 µg/ml blood.
[b] Pb 6–20 µg/g dry weight kidney; 6–30 µg/g dry weight liver; 0.2–1.0 µg/ml blood.
[c] Pb >20 µg/g dry weight kidney; >30 µg/g dry weight liver; >1.0 µg/ml blood.
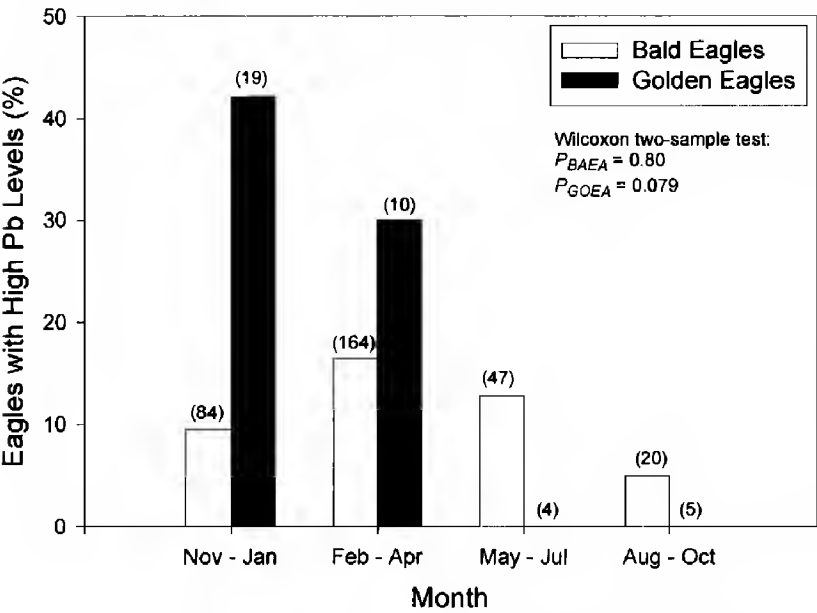
Figure 2. Temporal changes in the percent of Bald and Golden eagles with high Pb levels, in relation to the fall hunting season (September–December). High Pb levels were defined as >0.2 $\mu g/ml$ blood or >6 $\mu g/g$ dry weight liver or kidney tissue. Numbers in parentheses indicate sample sizes.

between those with background and high Pb levels ($P = 0.8$). Waterfowl hunting intensity did not affect the percent of Bald or Golden eagles with high Pb levels ($P \geq 0.48$). In areas of low intensity waterfowl hunting, 12.8% of Bald Eagles and 32.0% of Golden Eagles had high Pb levels. High Pb levels were evident in 14.1% of Bald Eagles and 21.4% of Golden Eagles recovered from high intensity waterfowl hunting areas.

Median and quartile Pb levels in kidneys of five eagles with Pb shot in their gastrointestinal tracts were 23.1 $\mu g/g$ and 20.8–76.8 $\mu g/g$, respectively, and were higher than in 329 eagles without shot in their gastrointestinal tracts (0.4 $\mu g/g$, 0.08–1.4 $\mu g/g$, Wilcoxon two-sample test: $P < 0.001$).

DISCUSSION

Causes of Death, Injury, or Illness. A sampling bias existed in this study because of the way in which eagles were found and reported. Thus, relative importance of each cause of death or morbidity may not be representative of the actual proportion at the population level. Birds affected by starvation and disease may be reclusive and susceptible to depredation (Wobeser 1994, 1997), thus, decreasing the probability of encounter by humans. Many eagles during this study were found in southwestern BC near major population centers, but few were obtained from northern breeding areas where human populations are sparse.

Prevalence of Pb poisoning, electrocution, trau-

Table 3. Causes of death or morbidity (percent of all cases) reported in eagles in the United States and in western Canada.

DIAGNOSIS	U.S.A. 1963– 84[a]	U.S.A. 1960s– 90s[b]	U.S.A. 1978– 81[c]	WESTERN CANADA 1986– 98[d]
Trauma	21	23[e] 27[f]	20	22
Pb poisoning	6	8	6	6
OP and carbamate poisonings	0.5	~3	0	8
Other poisonings	5	U[g]	1	1
Electrocution	9	12[e] 25[f]	15	11
Gunshot	23	15	19	7.6
Trapping	5	U	6	1
Emaciation	8	U	11	6
Disease	2	U	6	5 5
Undetermined	18	U	6	29

[a] $N = 1429$ Bald Eagles (National Wildlife Health Laboratory 1985).
[b] $N \sim 4300$ Bald and Golden eagles (Franson et al. 1995).
[c] $N = 293$ Bald Eagles (Reichel et al. 1984).
[d] $N = 546$ Bald and Golden eagles (this study).
[e] Bald Eagles.
[f] Golden Eagles.
[g] Unknown.

ma, emaciation, and disease as reported in this study in western Canada were similar to those previously reported for the United States (Table 3). The present study found that Pb poisoning accounted for 6% of diagnoses, a value that is in agreement with previous reports. Interestingly, we found that carbamate and OP insecticide poisonings in western Canada accounted for a much higher percent of cases than had been reported in the United States. Gunshot and trapping diagnoses accounted for a smaller percent of cases in western Canada than in the United States. Overall, the proportion of human-induced mortality and morbidity in this study (44% of all cases and 62% of cases with known diagnoses) was similar to that in other studies (Reichel et al. 1984, National Wildlife Health Laboratory 1985, Franson et al. 1995, Harmata et al. 1999). Results suggest humans are directly responsible for a large proportion of eagle deaths, but it is uncertain whether this is impacting eagle populations. There is no evidence that populations of either Bald or Golden eagles had de-

clined in western Canada through to the early
1980s (Gerrard 1983, Kirk 1996). Although no re-
cent data are available, remedial measures to re-
duce the numbers of eagles dying from human-
related causes may not be necessary for the
conservation of eagle populations.

In this study, eagles from the prairie provinces
were poisoned by insecticides more often than
those from BC. This regional variation was likely
due to differences in the manner in which carba-
mate and OP insecticides were used. Insecticide
poisoning in BC likely resulted from the appropri-
ate use of granular carbamate and OP insecticides
(Elliott et al. 1996, 1997). Furthermore, insecticide
poisoning in BC may have been reduced in the
latter years of this study by successful efforts that
were undertaken to remove the most toxic prod-
ucts from the market or to at least reduce their
use. In contrast, insecticide poisonings in the prai-
rie provinces have been attributed to the illegal use
of carbamate and OP insecticides in baits intended
to kill coyotes (*Canis latrans*; Bollinger and Mineau
1995). Twelve percent (22/177) of the eagles col-
lected from the prairie provinces were diagnosed
with pesticide poisoning. Assuming that these cases
all resulted from efforts to bait and kill coyotes, the
effect of this activity is greater in the prairie prov-
inces than has been documented for North Amer-
ica as a whole (5%, Bortolotti 1984c). The use of
poisons to kill predators of livestock continues to
be a problem for eagles in the prairie provinces.

Lead Exposure and Poisoning. Although 6% of
the eagles in this study were initially diagnosed as
Pb-poisoned, subsequent tissue analysis showed
that 10% of 372 eagles had concentrations indica-
tive of Pb poisoning. The principal reason for this
difference is that Pb poisoning cannot be properly
determined without analyzing tissues for Pb. Thir-
teen percent of the eagles from the prairie prov-
inces, for which post-mortem examination did not
identify a cause of death, had tissue Pb levels in-
dicative of Pb poisoning. Cause of death or mor-
bidity was undetermined for 158 eagles in this
study, and not all birds were analyzed for Pb. Thus,
diagnosis without tissue analysis may have under-
represented Pb poisoning as a mortality factor. The
10% estimate based on only those eagles for which
Pb levels were determined, may be more accurate.

At concentrations below those known to cause
mortality, Pb is immunotoxic and neurotoxic, can
cause behavioral deficits, and impair digestion and
feeding (Burger 1995). Thus, elevated concentra-

tions of Pb in birds may increase their susceptibility
to diseases and accidents, and impair their ability
to hunt, obtain food, and digest food. We did not
find evidence to support an association between
elevated Pb levels and the prevalence of disease,
emaciation, or physical injury in eagles. Similarly,
the known causes of raptor mortality in Great Brit-
ain were generally unrelated to elevated Pb expo-
sure (Pain et al. 1994).

Bald Eagles that were poisoned by other toxic
agents, principally OP and carbamate insecticides,
had higher kidney Pb concentrations than dis-
eased, emaciated, or injured birds. Scheuhammer
and Wilson (1990) reported that various cholines-
terase-inhibiting insecticides in combination with
Pb did not have an additive effect on d-aminole-
vulinic acid dehydratase (ALA-d) inhibition when
compared with the effects of Pb alone. The ALA-d
enzyme is sensitive to Pb and serves as an excellent
biomarker of Pb exposure (Scheuhammer and Wil-
son 1990). In this study, many insecticide-poisoned
Bald Eagles were found in areas where Pb expo-
sure was also comparatively high. The association
between tissue Pb levels and the prevalence of poi-
sonings by other toxic agents probably reflects a
greater possibility that birds from these areas will
be exposed through their diets to both Pb and in-
secticides. We doubt that sublethal Pb exposure in-
creases the susceptibility of eagles to insecticides.

In this study, high Pb levels were found in a
greater proportion of adult and subadult eagles
than immature eagles. In the United States, adult
females comprised 47% of all Pb-poisoned Bald Ea-
gles, but only 25% of the continental population,
indicating a particular sensitivity of this age-sex
group (U.S. Fish and Wildlife Service 1986). Fre-
quent exposure to Pb may result in age-related in-
creases in Pb concentrations in soft tissue (Pain et
al. 1994), and eagles in western Canada may be
exposed to Pb frequently enough to result in age-
related Pb accumulation. This may be an impor-
tant issue from the population perspective, because
eagles are long-lived and have a low annual repro-
ductive potential, so population levels are linked
to the survival of reproducing adults (Grier 1980,
Newton 1988).

Eagles with Pb shot in their gastrointestinal
tracts had much higher Pb levels than those with-
out shot in their gastrointestinal tracts. This sug-
gests that Pb ammunition is an important source
of Pb exposure in eagles in western Canada. Al-
though the majority of Pb-poisoned eagles did not

Table 4.   Summary of North American studies showing the prevalence of eagles with high Pb and Pb-poisoned tissue concentrations.

SPECIES	LOCATION	TISSUE ANALYZED (N)	HIGH PB[a] (PERCENT)	PBPOISONED[b] (PERCENT)	REFERENCE
Bald Eagle	Idaho	Liver (5)	83	83	Craig et al. 1990
	Montana	Blood (37)	86	5	Harmata and Restani 1995
	Minnesota	Blood (25)	96	28	Hennes 1985
	Montana & Saskatchewan	Blood (178)	19	1	Miller et al. 1998
	Western USA	Blood (120)	3[c]	NA[d]	Wiemeyer et al. 1989
	Western Canada	Blood, liver, kidney (333)	13	9	This study
Golden Eagle	Idaho	Liver (16)	56	44	Craig et al. 1990
	Idaho	Blood (178)	42	NA	Craig and Craig 1995
	Montana	Blood (86)	56	2	Harmata and Restani 1995
	California	Blood (162)	36	2	Pattee et al. 1990
	Western Canada	Blood, liver, kidney (39)	28	15	This study

[a] Pb >6 µg/g dry weight kidney or liver; >0.2 µg/ml blood.
[b] Pb >20 µg/g dry weight kidney; >30 µg/g dry weight liver; >1.0 µg/ml blood.
[c] Pb >0.4 µg/ml blood.
[d] NA—not available.

have Pb shot or fragments in their digestive tracts, there may have been ample time for regurgitation (Pattee et al. 1981) or complete digestion of the Pb fragments. Although the difference was not statistically significant, Golden Eagles with high Pb levels tended to be found during or soon after the fall hunting season, whereas those with background Pb levels were found more often long after hunting seasons had ended. Similar results have been reported for Golden Eagles in California (Pattee et al. 1990), Bald Eagles in the United States (Pattee and Hennes 1983, Wiemeyer et al. 1989) and BC (Elliott et al. 1992), and Western Marsh-Harrier (*Circus aeruginosus*) in Europe (Pain et al. 1993, 1997, Mateo et al. 1999). In our study, there was no relationship between Pb levels and the time of year when Bald Eagles were found. However, some Bald Eagles found in late winter or early spring may have died at the onset of winter, but were frozen and buried by snow for several months before being discovered. Furthermore, eagles ingesting Pb ammunition during or shortly after the hunting season may not have died until several weeks later (Pattee et al. 1981).

We tested the hypothesis that consumption of waterfowl is a major source of Pb exposure in eagles (Pattee and Hennes 1983) by examining elevated Pb levels in the context of waterfowl hunting intensity and interspecific dietary differences. We found no geographic evidence linking high Pb levels in eagles to the use of Pb shot for waterfowl hunting, suggesting that waterfowl is not their primary source of Pb. Alternatively, this lack of correlation may have resulted from eagles flying long distances in short time periods (McClelland et al. 1994, Brodeur et al. 1996) after ingesting Pb shot. Eagles may have consumed waterfowl and associated Pb shot in areas of high waterfowl hunting intensity, then flown to areas of low waterfowl hunting intensity before dying of Pb poisoning. In addition, the gradual phasing out of lead shot for waterfowl hunting in southwestern BC, beginning in 1998, may have reduced the likelyhood that lead shot-contaminated waterfowl would have been an important source of lead to Bald Eagles, many of which were recovered in that area during this study.

Bald and Golden eagles are opportunistic foragers that eat a wide variety of prey, but in North America, Bald Eagles feed mainly on fish and waterfowl (Stalmaster and Plettner 1992, Miller et al. 1998, Restani et al. 2000), while Golden Eagles

feed mainly on mammals and upland game birds (Olendorff 1976). If waterfowl were the primary source of Pb for eagles, one would expect to find a higher percentage of Bald Eagles with high Pb levels than Golden Eagles. In fact, this has been reported in several studies from the western United States (Table 4). In contrast, we found high Pb levels in 13% of Bald Eagles and 28% of Golden Eagles in western Canada. Kramer and Redig (1997) suggested that Pb poisoning in eagles in the north-central United States resulted mainly from their scavenging small mammals and large game. Pb shot and bullet fragments in game birds, small mammals, and large game carcasses constituted the major source of Pb for Golden Eagles (Pattee et al. 1990, Gjershaug 1992, Bezzel and Fünfstuck 1995, Harmata and Restani 1995, Kendall et al. 1996). Moreover, Pb-poisoned Bald Eagles in the Greater Yellowstone Ecosystem had ingested large caliber bullets while feeding on ungulate carcasses (Harmata et al. 1999). Our results, as well as those from the studies mentioned above, suggest that waterfowl is not the primary source of Pb for eagles in large areas of western North America. Banning the use of Pb shot for waterfowl hunting may not significantly reduce Pb poisoning in eagles, and the use of Pb ammunition for hunting mammals and upland game birds may continue to pose a risk to eagles and other raptor species in Canada.

In conclusion, we found that various physical injuries, electrocution, pesticide poisoning, gunshot wounds, and Pb poisoning were the most common diagnoses in Bald and Golden eagles in western Canada. Further monitoring of eagle mortality and populations are required to assess the population level impacts of these mortality factors. Although high Pb levels were associated with other toxicoses, there was no evidence to suggest that sublethal effects of Pb predisposed eagles to injury or disease. In comparison with immature eagles, a higher percent of adult and subadult eagles had high Pb levels. This difference among age classes may also have repercussions at the population level. We found no significant association between Pb levels and the fall hunting season, but we suspect that eagles in western Canada were exposed incidentally to Pb ammunition through the consumption of various prey species. Waterfowl appeared not to be the primary source of Pb for eagles in western Canada, and we suspect that Bald and Golden eagles will continue to be Pb-poisoned despite the ban on the use of Pb shot for waterfowl hunting.

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ABUNDANCE OF SOARING RAPTORS IN THE BRAZILIAN ATLANTIC RAINFOREST

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ABSTRACT.—18 August–4 September 1998, we conducted 23 3–4 hr point-counts in an Atlantic rainforest area of southeastern Brazil to evaluate the richness and relative abundance of raptors in two adjacent protected areas, Parque Estadual Intervales and the Parque Estadual Turístico do Alto Ribeira. During 88.2 hr, we recorded 334 contacts with raptors, involving 734 individuals of nine species. Contacts per hour and the number of species tallied showed that the counts were higher between 0900–1200 H (Local Standard Time), and that counts of 3 hr were the most cost effective. Reasonable precision for abundance indices was achieved with samples sizes of 20–30 points, but samples of 12 should give satisfactory results for the more common species, as long as counting points are distributed sufficiently in space. We derived abundance indices for species of raptors most commonly seen in the area. In 14 3-hr counts, Black Vultures (*Coragyps atratus*) were observed in 100% of them, Mantled Hawks (*Leucopternis polionota*) in 71%, Black Hawk-Eagles (*Spizaetus tyrannus*) in 50%, Turkey Vultures (*Cathartes aura*) in 29%, Ornate Hawk-Eagles (*Spizaetus ornatus*) in 21%, Roadside Hawks (*Buteo magnirostris*) in 14%, Short-tailed Hawks (*Buteo brachyurus*) in 14%, Crested Caracaras (*Polyborus plancus*) in 14%, and Tiny Hawks (*Accipiter superciliosus*) in 7%. Bat Falcons (*Falco rufigularis*) and White-tailed Hawks (*Buteo albicaudatus*) also were reported in the area, but outside the counting periods.

KEY WORDS: *Brazilian rainforest; point count; richness; São Paulo State.*

ABUNDANCIA DE RAPACES PLANEADORAS EN LA SELVA ATLÁNTICA BRASILEÑA

RESUMEN.—Entre el 18 de agosto–4 de septiembre de 1998, realizamos 23 censos puntales de 3–4 hr de duración en la selva Atlántica del Brasil, para estimar la riqueza y abundancia de aves de presa en dos zonas protegidas adyacentes, el Parque Estadual Intervales y el Parque Estadual Turístico do Alto Ribeira. Tras 88.2 hr de censo se obtuvieron 334 observaciones de rapaces correspondientes a 734 individuos de 9 especies. El número de contactos y de especies observadas indican que la mejor hora para realizar los censos se sitúa entre las 0900–1200 H (Hora Local Time) y que su duración óptima es de 3 hr. Una buena precisión en las estimas de abundancia se obtiene a partir de tamaños muestrales de 20–30 puntos, pero muestras de 12 puntos pueden ofrecer resultados satisfactorios para las especies más frecuentes, siempre y cuando los puntos se encuentren bien repartidos por el área de estudio. En catorce censos de tres horas llevados a cabo entre las 0900–1200 H, el Zopilote Negro (*Coragyps atratus*) se observó en el 100% de los censos, el Busardo Blanquinegro (*Leucopternis polionota*) en el 71%, el Aguila-Azor Negra (*Spizaetus tyrannus*) en el 50%, el Aura Gallipavo (*Cathartes aura*) en el 29%, el Aguila-Azor Galana (*Spizaetus ornatus*) en el 21%, el Busardo Caminero (*Buteo magnirostris*), el Busardo Colicorto (*Buteo brachyurus*), el Caracara Carancho (*Polyborus plancus*) en el 14%, y el Gavilancito Americano (*Accipiter superciliosus*) en el 7% los casos. El Halcón Murcielaguero (*Falco rufigularis*) y el Busardo Coliblanco (*Buteo albicaudatus*) fueron observados fuera de los períodos de censo.

[Traducción de los Autores]

The Atlantic rainforest of Brazil is one of the most threatened biomes in the world. Only 2–8% of the 10^6 km² of forest that once covered a narrow stretch of land along the southeastern coast of Brazil remains in scattered, small fragments (Fonseca 1985, Albuquerque 1995, Myers et al. 2000). One of the best-preserved areas of Atlantic rainforest is the Paranapiacaba forest fragment (140 000 ha) (Mateos et al. 2002). This fragment includes some areas of unprotected forest and four protected areas (Parque Estadual Turístico do Alto Ribeira, Parque Estadual Intervales, Parque Estadual Carlos

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Botelho, and Estação Ecológica Xitué) known as the Paranapiacaba Ecological Continuum (Pisciotta 2002), which, all together, form one of the largest remaining patches of uninterrupted Atlantic rainforest (Fig. 1).

In spite of its fragmentation, the Atlantic rainforest remains among the richest of all ornithological areas in the world (Cracraft 1985, Wege and Long 1995, Stattersfield et al. 1998) and is considered a hotspot for biodiversity conservation (Myers 1988, Bibby et al. 1992b, Myers et al. 2000). The area gives refuge to many endemic birds (Myers et al. 2000), among which are several species and subspecies of raptors such as Grey-headed Kites (*Leptodon cayanensis*), White-necked Hawks (*Leucopternis lacernulata*), Mantled Hawks (*Leucopternis polionota*), and Black Hawk-Eagles (*Spizaetus t. tyrannus*) (Collar et al. 1992, del Hoyo et al. 1994, Bierregaard 1998, Bildstein et al. 1998). This justifies the need for scientific and conservation initiatives to protect this important element of the global biodiversity (Burnham et al. 1994).

Raptors usually live at low densities and are difficult to detect, so that the methods usually employed to evaluate general bird populations are not adequate (Forsman and Solonen 1984, Thiollay 1989, Bibby et al. 1992a). Accurate species richness and abundance estimates require surveying large areas and conducting a large number of counts. The dense structure of the rainforest adds even more difficulty to the study of these raptors (Thiollay 1989), and a great deal of time and effort are often required to prepare and to conduct the counts (Whitacre and Turley 1990, Mañosa and Pedrocchi 1997).

For these reasons, the conservation status of many woodland raptors in the neotropics is poorly known (Albuquerque 1986, Thiollay 1994), in spite of the fact that more than half of the species of neotropical raptors are endangered (Thiollay 1985, Bildstein et al. 1998). Several research and monitoring programs are currently providing new information about raptors in tropical forests (Thiollay 1989, Vannini 1989, Whitacre and Thorstrom 1992), but only preliminary research has been conducted in the Atlantic rainforest (Willis and Oniki 1981, Guix et al. 1992, Mateos and Mañosa 1996, Mañosa and Pedrocchi 1997, Veilliard and Silva 2001, Mañosa et al. 2002).

Considering the need of improving our knowledge on raptor assemblages in Atlantic rainforest areas, as well as the need of achieving maximum accuracy of the results and efficiency of the counting effort, the objectives of our research were (1) to evaluate the effect of several variables (time of day, duration of counts, number of counts, selection of counting points) on the efficiency of the point-count method in estimating species richness and abundance indices of raptor assemblages in the Atlantic rainforest, and (2) to derive the best estimate of abundance indices of raptors in a well-preserved area of Brazilian Atlantic rainforest.

MATERIAL AND METHODS

Study Areas. Counts were conducted in two adjacent areas of the Parque Estadual Turístico do Alto Ribeira (Petar) and the Parque Estadual Intervales (Intervales), within the Paranapiacaba forest fragment in Serra do Mar mountain range, in the state of São Paulo, Brazil (Fig. 1). The Serra do Mar extends parallel to the Atlantic coast for over 900 km. Its slopes rise to abrupt mountain peaks between 800–1100 m in elevation. The Paranapiacaba forest fragment (Pisciotta 2002) consists of four legally-protected, neighboring reserves, known as the Paranapiacaba Ecological Continuum (1258 km²), plus some adjacent private forest areas. Together, they comprise some 1400 km² of uninterrupted forest in several ecological successional stages (Fig. 1). Most of the Paranapiacaba forest fragment is covered by Low Elevation South Hillside Atlantic rainforest (Guix 2002), typical of the altitudinal range between 50–100 m and 1200–1600 masl, and tree height ranging from 20–30 m. Some surrounding and marginal areas (near 10% of the total area) is planted *Araucaria angustifolia*, *Pinus* sp. and *Eucalyptus* sp. forest, banana plantations, and pastures. Four main vegetation types can be distinguished in the Paranapiacaba forest fragment: mature forests, which have been subject to no episode of deforestation or intensive selective extraction, or only a single one more than 80–100 yr ago; late-secondary forests, which suffered the last episode of deforestation or intensive selective extraction 50–80 yr ago; young-secondary forests, which suffered the last deforestation or selective extraction episode 20–40 yr ago; and "capoeiras" or shrublands, which are forest areas that have undergone the last deforestation episodes just 5–15 yr ago. The study area is covered by mature and secondary forest types. In some zones of shallow calcareous soil in the Petar site, mature or late-secondary forests are lower in stature than those of the same successional stages in Intervales.

The study area in Intervales was the main valley of the Formoso-Pilões River, from just above Base do Carmo to a few kilometers beyond Base do Alecrim (Fig. 1). The Atlantic rainforest in this valley is mature or late-secondary, with a mean height of 18 m and emergent trees reaching 24–30 m. Palmito (*Euterpe edulis*) is abundant but becomes scarcer at the bottom of the valley, where taquara (*Merostachys* sp.) is widespread. On mountain sides and summits and facing north northwest, the Atlantic rainforest is most intact and there is hardly any taquaral present. On the highest areas of the valley, near Base do Carmo, human influence is minimal or nonexistent: mature or old-secondary forests cover the region.
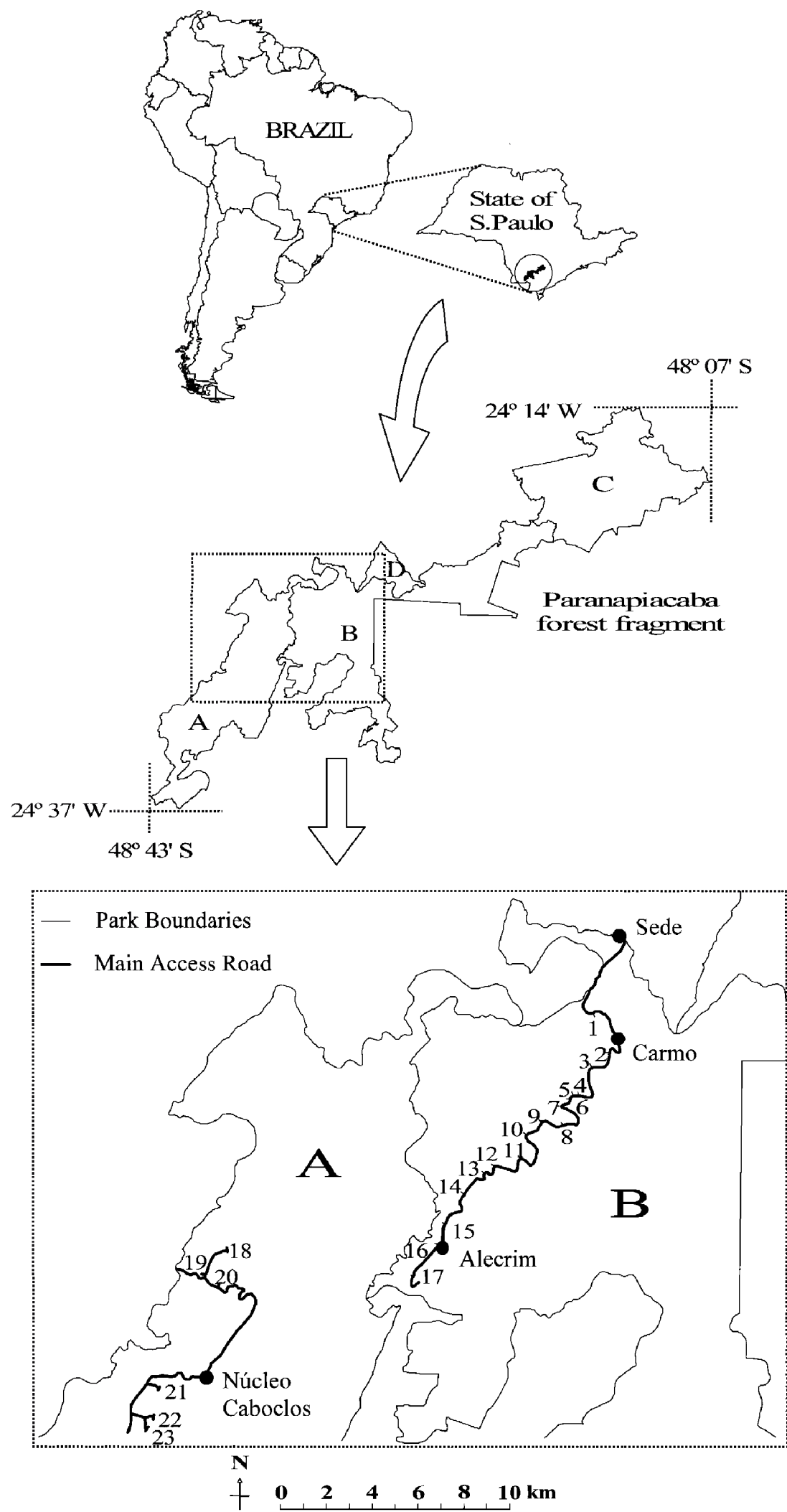
Figure 1. Location of the study area in Brazil. The limits of the four protected areas conforming the Ecological Continuum of the Paranapiacaba forest fragment within the São Paulo State are indicated. (A: Parque Estadual Turístico do Alto Ribeira; B: Parque Estadual, Intervales; C: Parque Estadual, Carlos Botelho; D: Estação Ecológica Xitué). The study area is outlined and enlarged, showing the location of the 23 counting points indicated by the numbers.

"Capoeiras" occur only along the main road and trails, due to the extraction of palmito palms and wood. The valley bottom near Alecrim has been inhabited and modified for centuries. Late-secondary forest dominates this region, with a scattering of small banana plantations. Taquaral areas around Alecrim are the remains of opened areas used for subsistence farming 15–25 yr ago.

The study area in Parque Estadual Turístico do Alto Ribeira was adjacent to the village of Núcleo Caboclos (Fig. 1). The Núcleo Caboclos is 600 masl and is covered by typical Hillside Atlantic rainforest vegetation (Carvalho et al. 2002) with a high botanical diversity. This high diversity is caused by the existence of calcareous sediments that enhance the growth of forests with a particular floristic composition. Secondary vegetation grows in the margins of dirt tracks and trails; it is characterized by taquaral and shrublands.

Field Procedures. The point-count method (Whitacre and Turley 1990, Whitacre et al. 1992a) was used because it was the most effective method in a preliminary survey in 1994 (Mañosa and Pedrocchi 1997). Counts were conducted during the dry season, between 18 August and 4 September 1998, when some raptors (i.e., Mantled Hawk, Black Hawk-Eagle) are expected to be displaying in the area (Vielliard and Silva 2001). One or two observers stayed on high points of the landscape or perched on the tops of trees, having a view angle of 80–294° and a range of view above the canopy of 1000–4000 m. We selected 23 points along main tracks or footpaths (Fig. 1), which we judged to be representative of the dominant habitat in the area. Seventeen of these points were along 27 km of the Formoso-Pilões Valley and six around the Caboclos area. Each point was selected in order to give an independent view of a part of the study area. The mean distance between neighboring points was 997 ± 441 m (SD) in Intervales (range = 267–1493) and 1900 ± 1665 m in Petar (range = 600–5161). Even the closest points offered non-overlapping views of the study area. The counts were initiated between 0800–1200 H (Local Standard Time, sunrise 0519 H), and lasted for 2.5–4 hr. The mean length of the counts was 3.8 ± 0.4 hr (SD). Each point was sampled only once. The 23 counts totalled 88.2 hr of observation, concentrated from 0900–1300 H (72.1 hr). Counts were conducted in clear weather, except for one that was conducted in light rain but yielded comparable results. During each count interval, we recorded every raptor in view to an unbounded distance. In this manner, we obtained a list of the minimum number of individuals and groups observed during every count.

Computation of Relative Abundance Parameters. We computed the following abundance indices for each species and area: percentage of counting points in which a species was detected (percent presence ±95% Confidence Interval [CI]), mean group size (individuals ± SD), and contacts/hr (±95% CI). Confidence intervals were computed by bootstrap techniques, using the *Resampling Stats* suite (Bruce et al. 1995): a parameter value was computed for each original counting point. This gave an initial sample of values, which was randomly resampled with replacement to obtain a sample size identical to the original one. This process was repeated 10 000 times. Then, the mean and confidence intervals of the 10 000 parameter estimates were obtained.

Evaluation of Biases. The effect of the time of day (morning only) on the results of the counts was evaluated by analyzing the number of species reported at several hourly intervals. For species in which the number of observations was large (Mantled Hawk, Black Vulture, Turkey Vulture, and Black Hawk-Eagle), an hourly reporting pattern was also obtained. An index of activity was computed for each hourly interval and species. Each hourly period of observation was divided into twelve 5-min intervals. During each interval, we recorded the number of individuals in view. The activity index for a given species during a specific hourly interval was the product of the proportion of 5-min intervals in which the species was in view during that period (from 0/12–12/12) by the addition of all individuals recorded during the twelve 5-min intervals.

To assess the optimal duration of counts, we analyzed how the number of detected species and abundance indices estimates changed in relation to count duration. We limited this analysis to the counts initiated at 0900 H and that were extended to 1300 H ($N = 9$), so that the effect of sampling at different times of day was removed.

The relationship between precision of estimates and sample size was modelled using bootstrapping techniques (see above) by taking samples of progressively increasing size (1–50). To evaluate how the precision of the abundance indices improved with sample size, the ±95% CI of these estimates were plotted against the number of counts. To make comparisons between parameters and species possible, precision was expressed as (upper 95% CI − lower 95% CI)/mean.

To test how the selection of the counting points could affect the results, we divided our initial set of 23 points into two sets of spatially alternating points, a set of 12 (set A) and a set of 11 (set B) points. These two data subsets were used to derive two separate estimates of the relative-abundance parameters. Comparison between these two sets should give some indication of the reproducibility and accuracy of our results.

Computing Standard Abundance Estimates. Standardized abundance indices estimates of raptors for the study area as a whole and for each of the two Preserve Areas were derived, considering only the 14 counts in the 0900–1200 H period. The remaining nine counts were omitted because they lasted for less than three hours or because they did not include the above-mentioned period.

RESULTS

We recorded 11 raptor species in the Paranapiacaba forest fragment, two of which, the Bat Falcon (*Falco rufigularis*) and the White-tailed Hawk (*Buteo albicaudatus*), were observed for the first time in the area (Table 1). The 23 counts yielded 334 observations of raptors (3.8 contacts/hr) involving 734 individuals, belonging to nine species of raptors (Table 2). Only one of the 23 counts (4%) resulted in no raptor observations, four yielded one species, five yielded two species, four yielded

Table 1. Composition of the raptor assemblage in the Paranapiacaba forest fragment, according to the species recorded in several surveys to the area. "x" indicates the species was recorded outside the primary sample periods. Vagrant species, as well as migratory species that are absent from the area in August, are excluded.

	WILLIS AND ONIKI (1981)[a]	VIELLIARD AND SILVA (2001)[b]	MAÑOSA ET AL. (1997)[c]	This study[d]
Black Vulture (*Coragyps atratus*)	49	100%	50%	100%
Turkey Vulture (*Cathartes aura*)		59%	x	29%
Grey-headed Kite (*Leptodon cayanensis*)		9%	?[e]	
Rufous-thighed Kite (*Harpagus diodon*)		18%		
Grey-bellied Goshawk (*Accipiter poliogaster*)		14%		
Tiny Hawk (*Accipiter superciliosus*)			25%	7%
Sharp-shinned Hawk (*Accipiter striatus*)		x		
Crane Hawk (*Geranospiza caerulescens*)		x		
Mantled Hawk (*Leucopternis polionota*)	2	86%	50%	71%
Great Black-Hawk (*Buteogallus urubitinga*)		4%		
Black-chested Buzzard-Eagle (*Geranoaetus melanoleucus*)		x		
Roadside Hawk (*Buteo magnirostris*)	34	95%	x	14%
White-rumped Hawk (*Buteo leucorrhous*)	2	x		
Short-tailed Hawk (*Buteo brachyurus*)	7	54%	x	14%
White-tailed Hawk (*Buteo albicaudatus*)				x
Guiana Crested Eagle (*Morphnus guianensis*)		x		
Black Hawk-Eagle (*Spizaetus tyrannus*)		68%	x	50%
Ornate Hawk-Eagle (*Spizaetus ornatus*)			25%	21%
Crested Caracara (*Polyborus plancus*)	2	18%		14%
Chimango Caracara (*Milvago chimachima*)	17	54%	x	
Laughing Falcon (*Herpetotheres cachinnans*)	5	x		
Barred Forest-Falcon (*Micrastur ruficollis*)	10	77%		
Collared Forest-Falcon (*Micrastur semitorquatus*)		4%	x	
Bat Falcon (*Falco rufigularis*)				x

[a] Individuals/100 hr observation (N = 41.2 hr) reported in the Carlos Botelho area between 24–28 February and 5–10 July 1979 (Swallow-tailed Kite [*Elanoides forficatus* excluded]).

[b] Percent of 22 visits to the Intervales area between August 1988 and December 1992 in which the species were reported. "x" indicates presence during other occasional visits to the area (Osprey [*Pandion haliaetus*], Swallow-tailed Kite, and Plumbeous Kite [*Ictinia plumbea* excluded]).

[c] Percent of point counts (N = 4) in which the species was detected during a visit to Intervales between 1 and 12 August 1994. "x" indicates detection outside the counts.

[d] Percent of point counts (N = 14) in which the species was detected during a visit to Intervales and the Petar in August–September 1998. "x" indicates detection outside the counts.

[e] Identification was uncertain.

three species, six yielded four species, and three yielded five species.

Effect of Time of Day. Only Mantled Hawks and Roadside Hawks (*Buteo magnirostris*) were observed before 0900 H. Although observation effort was minimal, only Black Vultures were consistently observed during the afternoon (1300–1600 H). The activity of this species remained more or less constant from 1000 H onwards (Fig. 2). Comparatively, the activity of Turkey Vultures was more concentrated around mid-day. Activity of Mantled Hawks remained constant during the morning and early afternoon, whereas the activity of Black Hawk-Eagles tended to be maximum between 0900 and 1200 H. Overall, the period 1000–1200 H embraced the peak activity periods of the three most common species, as well as all the observations of Short-tailed Hawks (*Buteo brachyurus*). A high percentage of the records of the less detectable species, such as Tiny Hawks (*Accipiter superciliosus*, 100%, N = 1), Crested Caracaras (*Polyborus plancus*, 50%, N = 2), and Ornate Hawk-Eagles (*Spizaetus ornatus*, 50%, N = 4) were concentrated between 0900 and 1000 H.

Table 2. Raptor abundance indices in Parque Estadual Intervales, Parque Estudual Turístico do Alto Ribeira and pooled estimate. Means and ±95% Confidence Intervals are given in parenthesis. N is the number of counts.

	INTERVALES ($N = 9$)	PETAR ($N = 5$)	POOLED ($N = 14$)
Hours of observation	27	15	42
Number of species	8	8	9
Black Vulture			
Contacts/hr	2.5 (1.5–3.7)	3.3 (2.3–4.2)	2.8 (2.0–3.6)
Percent presence	100 (100–100)	100 (100–100)	100 (100–100)
Mantled Hawk			
Contacts/hr	0.7 (0.3–1.3)	0.8 (0.4–1.2)	0.8 (0.4–1.2)
Percent presence	67 (33–100)	80 (40–100)	71 (50–93)
Black Hawk-Eagle			
Contacts/hr	0.6 (0.1–1.2)	0.7 (0.1–1.4)	0.6 (0.2–1.1)
Percent presence	44 (11–78)	60 (20–100)	50 (21–79)
Turkey Vulture			
Contacts/hr[a]	<0.1 (0.0–0.1)	0.5 (0.1–0.8)	0.2 (0.05–0.4)
Percent presence	11 (0.00–33)	60 (20–100)	29 (7–57)
Roadside Hawk			
Contacts/hr	0.2 (0.0–0.6)	0.1 (0.0–0.2)	0.1 (0.0–0.4)
Percent presence	11 (0–33)	20 (0–60)	14 (0–36)
Ornate Hawk-Eagle			
Contacts/hr	<0.1 (0.0–0.1)	0.1 (0.0–0.3)	0.1 (0.0–0.1)
Percent presence	11 (0–33)	40 (0–80)	21 (0–43)
Short-tailed Hawk			
Contacts/hr	0.0	0.2 (0.0–0.5)	0.1 (0.0–0.2)
Percent presence	0	40 (0–80)	14 (0–36)
Crested Caracara			
Contacts/hr	<0.1 (0.0–0.1)	0.1 (0.0–0.2)	0.05 (0.0–0.1)
Percent presence	11 (0–33)	20 (0–60)	14 (0–36)
Tiny Hawk			
Contacts/hr	<0.1 (0.0–0.1)	0.0	0.02 (0.0–0.1)
Percent presence	11 (0–33)	0	7 (0–21)

[a] Significant differences between areas at $P < 0.05$; Kruskal-Wallis test.

Effect of Count Duration. The number of species observed (±95% CI) tended to increase as the duration of the counts increased from 1 hr (1.4 ± 0.5 species) to 2 hr (2.7 ± 0.9), but leveled off progressively for 3 hr (3.0 ± 0.9) and 4 hr counts (3.2 ± 1.0). Among the four more frequent species, the cumulative percentage of counts levelled off after 2–3 hr of sampling for the Black Vulture and the Black Hawk-Eagle. For the Turkey Vulture and the Mantled Hawk, this parameter increased slightly, although not significantly, during the fourth hour of the count (Fig. 3).

Effect of the Number of Counts. The number of species detected increased quickly with the number of counts. Some 20 counts were needed to detect 90% of the total species documented, but the rate of addition of new species was low with the addition of more counts (Fig. 4). Precision of abundance indices estimates quickly increased with sample size (Fig. 5). For the more frequent species (i.e., percent presence 70–100%: Black Vultures, Mantled Hawks), the precision of the abundance estimates falls below one ±95% CI of the mean after 12 counts. For species with <30% presence
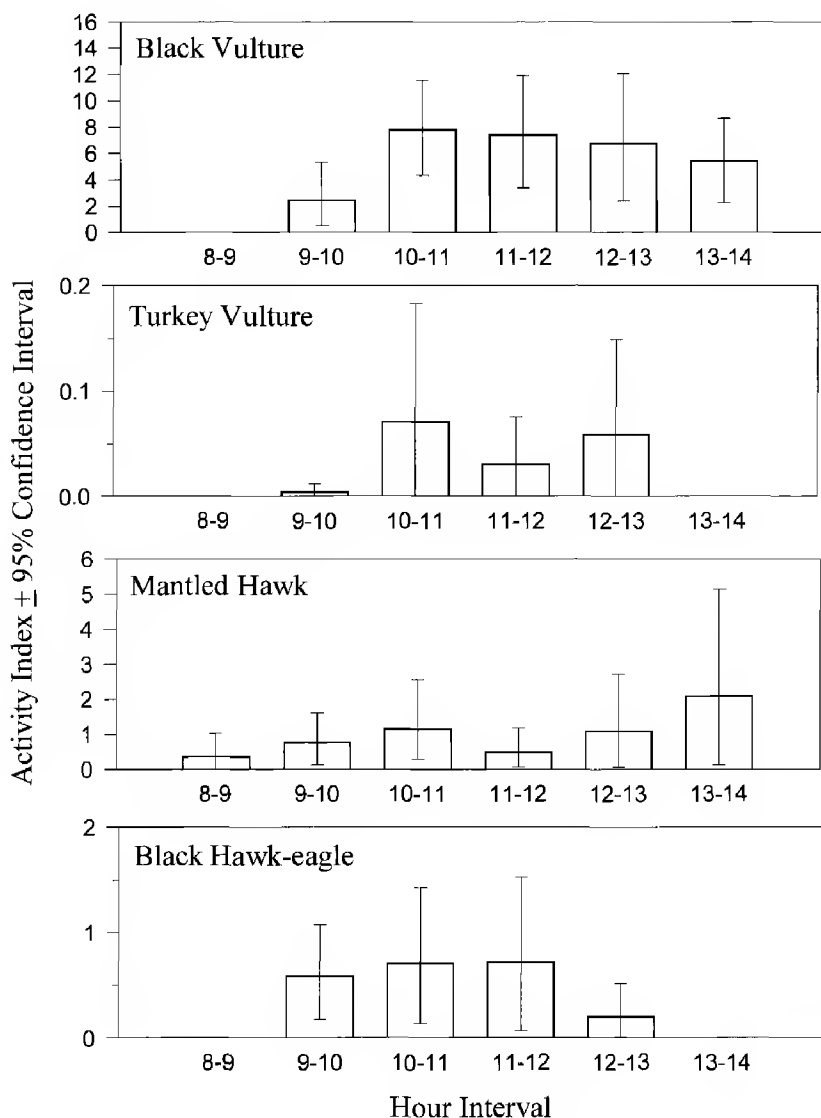
Figure 2. Hourly variation (Local Standard Time) of the activity index of the most common species in the study area (both sites combined). For a given hour period, the activity index for each species was computed as the product of the proportion of 5-min intervals in which the species was in view by the total number of individuals observed. Sunrise = 0519 Local Standard Time.
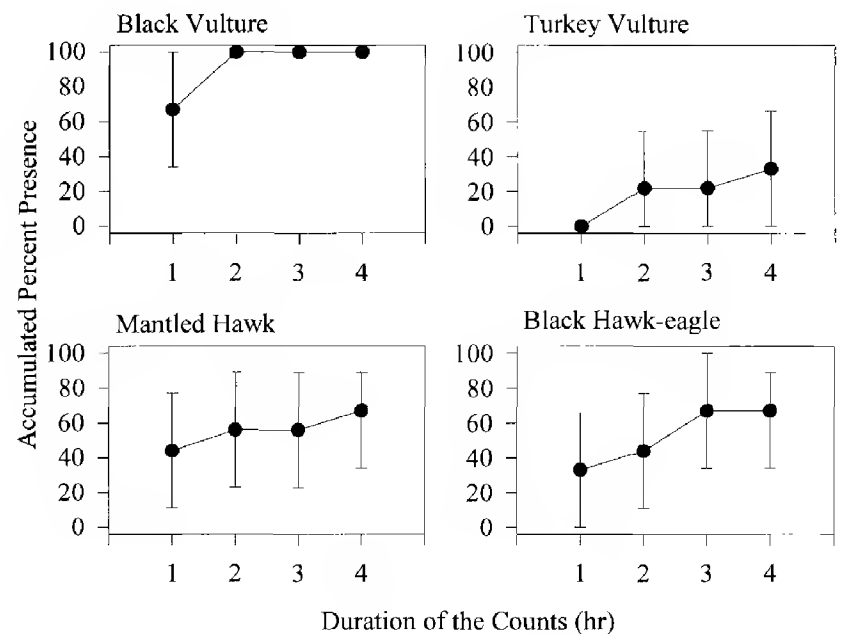

Figure 3. Simulation of cumulative percent presence of the most frequently-detected species in relation to the duration of counts (hr). All counts began at 0900 H Computations are based on the same nine point counts

(i.e., Turkey Vulture), more than 50 samples are needed to reach such a precision value. However, the rate of increase in precision of parameter estimates is very low after 10–20 counts. At any given sample size, percent presence was slightly more precise than contacts/hr.

Reproducibility of Results. For the data set including all the counting points the mean distance between neighboring points (SD) was 1.2 ± 1.0 km (range = 0.3–5.2 km). For the two subsets of alternating points, these distances increased to 2.4 ± 1.3 km (range = 0.8–6.0 km) for subset A and 2.4 ± 1.6 km (range = 0.5–6.45 km) for subset B. Only the three most common species were detected in both subsets that, because of small sample size, yielded only five and six species, respectively. Abundance indices estimates based on these separate data sets had larger confidence intervals than es-

timates from the overall sample, but were not significantly different from one another, nor from the pooled estimate.

Composition of the Raptor Assemblage. During the fourteen standardized counts conducted between 0900 H and 1200 H, nine raptor species were detected (Table 2) of the 24 that have been reported in the area in this and in previous surveys (Willis and Oniki 1981, Mañosa and Pedrocchi 1997, Vielliard and Silva 2001; Table 1). Four species are reported in the four lists, four species in three, six species in two, and 10 species in only one. Of the 15 potential species which were missed in our point counts, only five had been reported
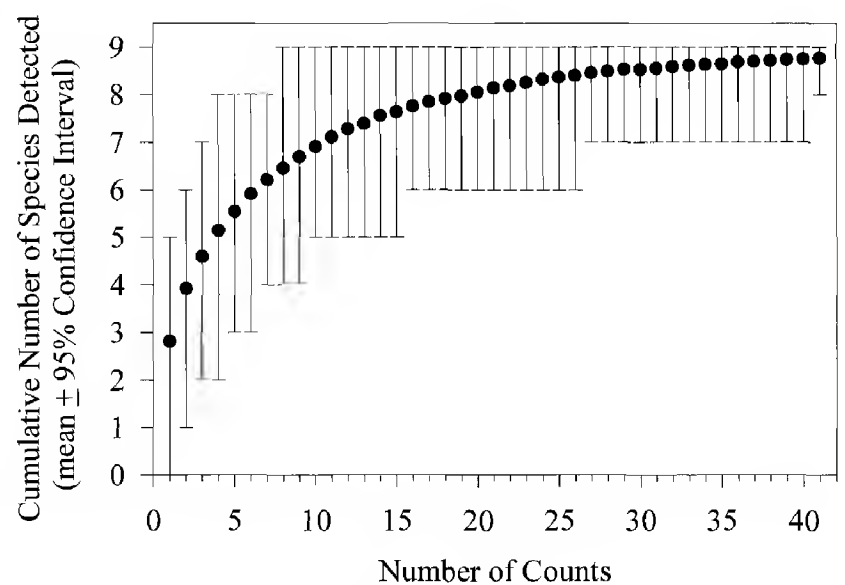

Figure 4. Simulation of the cumulative number of species detected in relation to the number of counts.
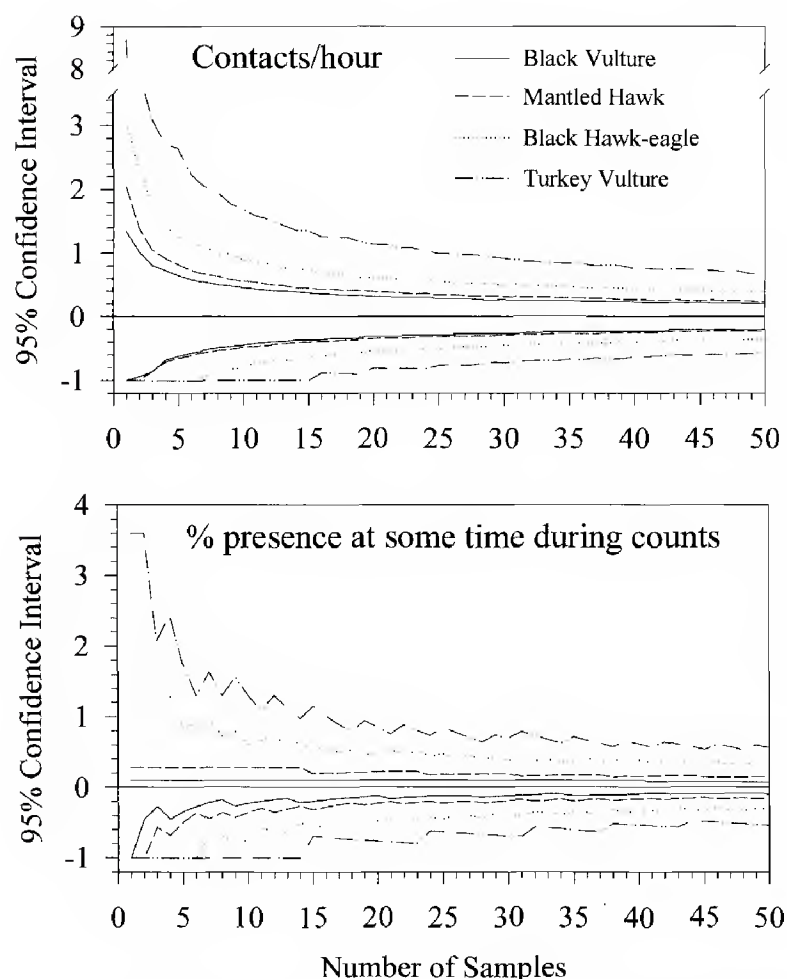
Figure 5. Simulation of the increase in precision of estimates around the means (mean = 0) of contacts/hour and percent presence estimates in relation to number of counts for the four most common species in the area. The ±95% Confidence Interval of the mean is expressed as multiples of the mean (Upper 95% Confidence Interval − Lower 95% Confidence Interval/Mean) and plotted against sample size.

in more than one previous survey, and only one species in more than two studies (Table 1).

The results of the fourteen standardized counts (Table 2) indicated that the Black Vulture was the most frequently detected species, involving 118 (59%) contacts. The species was usually observed flying in groups of 2–12 individuals (2.6 ± 1.7 birds/group). Only 26% of the observations of this species involved single birds. Mantled Hawks accounted for 31 (16%) contacts with groups of 1 or 2 birds (1.2 ± 0.4 birds/group). Black Hawk-Eagles involved 26 (13%) contacts of single birds or pairs (1.2 ± 0.4 birds/group). The remaining species each accounted for less than 5% of the records.

Both preserve areas showed similar species composition, but among the species with more than one record, the Short-tailed Hawk was reported only in Petar. All species tended to be more abundant in Petar than in Intervales (Table 2), al-

though the difference was only significant for the Turkey Vulture.

DISCUSSION

The timing, duration, efficiency of, and number of point counts is important in obtaining an optimal balance between sampling effort and an adequate description of raptor assemblages. If extended count periods do not result in the detection of more species, then additional time would be best invested in sampling a larger area or searching and installing additional points. Within a counting point, time should be limited to that needed to detect all species active on a given morning. In our counts, every few species were detected before 0900 H, whereas, after 1200 H detection frequency of most raptors, including the Black Hawk-Eagle, declined. Counts of less than 3 hr duration had a high probability of missing some species, but after three counting hours, no new species were detected. Also, for the common species, abundance indices stabilize after the third hour of the count. This indicates that the best cost-effective alternatives may be conducting 3-hr counts from 0900–1200 H (Local Standard Time), that is between 3 hr 41 min and 6 hr 41 min after sunrise, a bit later than what has been found in other rainforest areas (Whitacre and Turley 1990, Whitacre and Thorstrom 1992).

The number of counts is related to the number of species that would be detected (Whitacre and Turley 1990) and how well the raptor assemblage is characterized. It is also important in determining the precision of the abundance estimates (Bibby et al. 1992a). Accuracy and precision in monitoring programs is needed to detect small differences between years, habitats, or areas. However, after a certain level of precision is reached, further improvement can only be achieved at a high cost. Our results indicate that the more detectable species are found with few counts, but that sample sizes of 11–12 points may still miss some important, though less detectable, species. With 20 points, 90% of the more-detectable species are identified, but more than half the potential species present in the area are still missed (Table 1). On the other hand, 12 counts may provide abundance indices within one ±95% CI of the mean, but only for the two most common species (Black Vulture, Mantled Hawk). A minimum of 20–30 counts would be needed to obtain comparable precision for the next most frequently-detected species (Black

Hawk-Eagle). Precise abundance estimates for the still less detectable raptors would only be obtained at the expense of much more sampling effort (>50 counts), which also would be needed to detect additional species or to slightly improve the precision of the estimates of more common species.

Bias in the selection of counting points may also have an effect on the estimation of species richness and on the accuracy of abundance estimates. This bias can arise from selecting points not representative of the area being surveyed, or from excessive proximity of sampling points, which may result in double counting of territorial raptors. Comparison of two subsets of our data points suggests that for the most detectable species, species richness was little affected by the reduction of number and placement of counting points, and that relative abundance estimates were also not altered.

Counts were conducted at the start of the nesting season, when raptors were most active and probably when the point count method was most effective (Whitacre and Turley 1990). However, during the counts we only detected nine of the 24 species potentially present in the area (Table 1). Most of the remaining species seem to be relatively uncommon, but some may have been missed because of the timing of the counts. This may be the case of Grey-headed Kite (*Leptodon cayanensis*), which generally displays early in the breeding season (October, according to Vielliard and Silva [2001] and Whitacre pers. comm.). Small size may account for the absence from our list of Rufous-thighed Kite (*Harpagus diodon*), which was relatively frequent in some previous surveys. The point-count method may also overlook non-soaring species, which would explain why Tiny Hawks, Bat Falcons, forest-falcons (*Micrastur sp.*), and Crested Eagles (*Morphnus guianensis*) were not detected. For these species, the use of acoustical luring or pre-dawn listening may be more effective (Whitacre and Turley 1990).

Comparing all raptor surveys available from the area (Willis and Oniki 1981, Mañosa et al. 1997, Vielliard and Silva 2001; Table 1), the Black Vulture appears as the most common species. The Roadside Hawk emerged as the second most-frequently-detected species in Willis and Oniki (1981) and Vielliard and Silva (2001) studies, instead of the Mantled Hawk, which ranked second in our survey. This difference may indicate temporal changes in species abundance or, more likely, differences in the methods and habitats sampled.

These differences may also explain the surprising absence of the Ornate Hawk-Eagle from the Willis and Oniki (1981) and Vielliard and Silva (2001) surveys. On the other hand, we were unable to detect some species that may be relatively common in the area, such as forest-falcons and the Chimango Caracara (*Milvago chimachima*). Other raptor species we may have missed that have been reported from other Atlantic rainforest areas are the Bicolored Hawk (*Accipiter bicolor*) (Willis and Oniki 1981), the White-necked Hawk and the Harpy Eagle (*Harpia harpyja*) (Albuquerque 1995).

The point count method provides only indices of species abundance rather than information on population densities. Theoretically, these measures should be related, but detectability may differ between species, so comparisons of detection rates are most reasonable between species of similar size and behavior (Thiollay 1989). Different soaring propensities, behavior, and body size of the different species largely affect detectability during point counts. This is especially true because we used an unlimited observation radius, which favors larger species at the expense of smaller ones. Thus, the point-count method may overestimate the abundance of larger and wide-ranging species (eagles, vultures) in relation to those of the smaller raptors (Jullien and Thiollay 1996).

Both the Intervales and Petar protected areas may support similar raptor assemblages, although some raptors, in particular the Turkey Vulture, tended to be more abundant in Petar than in Intervales. The relatively high abundance of open-country species reveals the effect of human settlement in the area and the relative proximity of open habitat near the preserves. In spite of this influence, the Mantled Hawk, an endemic species of the Atlantic rainforest, was found to be common in the area. Hawk-eagles also were common, particularly the Black Hawk-Eagle, a specialist of secondary or disturbed forest patches (Jullien and Thiollay 1996, Thiollay 1999). The Ornate Hawk-Eagle, which is thought to be restricted to little-disturbed forest (Jullien and Thiollay 1996), was less frequently observed than the Black Hawk-Eagle. This difference in detections of these two species may reflect the dominance of late-secondary forest in the area, but also the lower soaring propensity (del Hoyo et al. 1994) and detectability of Ornate Hawk-Eagle, even in areas where it is more abundant than the former species (D. Whitacre pers. comm.). Mean percent presence of hawk-ea-

gles was higher and the presence of *Buteo* hawks lower in the Paranapiacaba fragment than in several rainforest areas where raptor counts have been conducted in Central America (Jones and Sutter 1992, Whitacre et al. 1992b). Also, the Black Vulture may be relatively more abundant and Turkey Vulture less abundant than in the Central American study sites. These differences may indicate differences in habitats among areas or reflect different degrees of modification among sites.

The results of these counts confirm the importance of the ecological continuum of the Paranapiacaba fragment for the conservation of endangered raptors in the Brazilian Atlantic rainforest. The area supports relatively abundant populations of the Mantled Hawk, a poorly known species (Thiollay 1985, IUCN 1990), which is considered endangered (Thiollay 1994) or nearly endangered (Collar et al. 1992, del Hoyo et al. 1994). The relatively frequent detections of two other poorly-known species, the Ornate and the Black Hawk-Eagles (Bildstein et al. 1998), also is notable. Particularly as the subspecies of Black Hawk-Eagle, which was documented, is an endemic of the Brazilian Atlantic rainforest (Bierregaard 1998). Further fragmentation of the Paranapiacaba forest may severely impact populations of these poorly-studied species. Although changes on the populations of the rare or less detectable species may not be adequately tracked with this general point-count technique, standardization of the counting method would allow the implementation of monitoring programs with the objective to detect trends of some of the more detectable species, such as Mantled Hawks and hawk-eagles. Importantly, these species are of conservation concern and may be good indicators of habitat changes in the Atlantic rainforest relevant to the entire raptor assemblage.

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DIFFERENTIAL SPRING MIGRATION OF ADULT AND JUVENILE LEVANT SPARROWHAWKS (*ACCIPITER BREVIPES*) THROUGH EILAT, ISRAEL

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Abstract.—As many as 50 000 Levant Sparrowhawks (*Accipiter brevipes*) are counted during migration at the northern end of the Gulf of Aqaba each spring. We present data from 1819 migrants that were captured and ringed at Eilat, Israel: 459 from 1984–88, 21 from 1989–95, and 1345 captured from 1996–2000. Of these, 396 (22%) were adult females, 631 (35%) were adult males, 359 (20%) were juvenile females, and 433 (24%) were juvenile males. We compare migration timing and body sizes in juvenile (i.e., first-time spring migrants) and adult migrants, and in males and females. Wing chord length and body mass in males and females changed significantly with date of arrival. Further, a significant correlation was found for both sexes between wing chord length and body mass in spring. Within age classes, both wing chord and body mass declined significantly with date of ringing. Body mass was also significantly related to size obtained from PCA analyses (PC1), both in males and females. We computed also standardized residuals of body mass on PC1. Date of passage was also significantly correlated to the standardized residuals, both in males and females. This suggested, testing for allometry vs. isometry, that birds in better than expected 'condition' migrated earlier. Moreover, results from analysis of variance revealed that body mass and age were significantly related to the date of passage. The median date of passage for adults preceded that of juveniles by 2.5 days. We believe juveniles on their first spring passage migrate slower than adults and that they are more likely to be later and in poorer body condition.

Key Words: *Levant Sparrowhawk*; Accipiter brevipes; *age*; *Eilat, Israel*; *sex*; *spring migration*.

MIGRACIÓN DIFERENCIAL DE PRIMAVERA ENTRE ADULTOS JUVENILES DEL AZOR DEL MEDITERRÁNEO ORIENTAL (*ACCIPITER BREVIPES*) A TRAVES DE EILAT, ISRAEL

Resumen.—Tantos como 50 000 azores del mediterráneo oriental (*Accipiter brevipes*) son contados durante su migración en el limite del golfo de Aqaba cada primavera. Presentamos datos de 1819 emigrantes que fueron capturados y anillados en Eilat, Israel: 459 de 1984–88, 21 de 1989–95, y 1345 capturados entre 1996–2000. De estos, 396 (22%) fueron hembras adultas, 631 (35%) eran machos adultos, 359 (20%) hembras juveniles, y 433 (24%) machos juveniles. Comparamos el tiempo de migración y los tamaños del cuerpo en emigrantes juveniles (v.gr., azores migrantes que lo hacían por primera vez en primavera) y adultos, y en machos y hembras. La longitud de la cuerda del ala y la masa del cuerpo en

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machos y hembras cambió significativamente con la fecha de arribo. Por otro lado, se encontró una correlación significativa para ambos sexos entre la longitud de la cuerda del ala y la masa corporal en primavera. Dentro de las clases de edad, tanto la longitud de la cuerda del ala como la masa del cuerpo declinó significativamente con la fecha del anillado. Las masas corporales además estuvieron relacion-adas significativamente al tamaño obtenido mediante análisis PCA (PC1), tanto en machos como hem-bras. Calculamos además residuos estandarizados de masa corporal en PC1. La fecha de paso estuvo también correlacionada significativamente con los residuos estandarizados, tanto en machos como en hembras. Esto sugiere, haciendo pruebas de alometría vs. isometría, que las aves en mejor "condición" que la esperada, migraban más temprano. Por otra parte, los resultados del análisis de varianza revelan que la masa del cuerpo y la edad estuvieron relacionadas significativamente con la fecha de paso. La fecha promedio para los adultos precedía a la de los juveniles en 2.5 días. Creemos que los juveniles en su primera pasada de primavera migran mas lento que los adultos y que son más propensos a estar retrasados y en condiciones corporales mas pobres.

[Traducción de César Márquez]

The Levant Sparrowhawk (*Accipiter brevipes*) breeds principally within the western Palearctic Region, in southeast Europe, locally through Turkey to northern Iran, and is widespread in southwest Russia and Kazakhastan (Snow and Perrins 1998). It winters in the east Sahel of sub-Saharan Africa, and sporadic reports are received also from the Ethiopian highlands and the southern Arabian Peninsula (Snow and Perrins 1998, Shirihai et al. 2000). Principal migration routes lie entirely within the Middle East (Frumkin et al. 1995, Shirihai et al. 2000) with especially large concentrations found at Eilat during spring (Shirihai and Christie 1992, Yosef 1995).

In Israel, the Levant Sparrowhawk is an abundant migrant in both spring and autumn and about 90% of the world population of the species passes through Israel within a short period of a fortnight (Shirihai et al. 2000), and this is the only raptor known to migrate at night in the region (Stark and Liechti 1993). Visible migration surveys conducted since 1977 suggest that Eilat is an important stopover site for the species in spring. Eilat is at the northern edge of the Sahara and Sinai deserts, and in spring many northbound migrants stop there to rest and feed (Safriel 1968, Yosef 1996a). Levant Sparrowhawks were trapped and ringed at and around Eilat during spring (mid-April through early May) from 1984–2000 (Clark and Yosef 1997, Yosef and Fornasari 2000). In this paper, we present morphometric data collected after capture to compare age- and sex-related differences in body size and migration timing in this species.

STUDY AREA AND METHODS

Levant Sparrowhawks were captured and ringed at and around Eilat, Israel (29°33'N, 34°57'E), using bow-nets, mist nets, dho-gazas, box traps, and Bal-chatri traps (Clark and Yosef 1997). All data were pooled because 63% of Levant Sparrowhawks were caught in 7-m-high mist nets in the early mornings when the flocks started the day's migration. We assumed that these birds represent a sample of the general population because the majority was not trapped with food as bait (Gorney et al 1999). All captured individuals were aged, sexed, measured (including unflattened wing chord), and weighed Aging was based on plumage, molt, and iris color (Clark and Yosef 1998). In addition, birds divided into two categories: juveniles—in second calendar year (SY) and adults—after second calendar year (ASY). Data presented in this paper were collected during 1984–88 (Gorney and Yom Tov 1994, Gorney et al. 1999), 1989–95 (Yosef and Fornasari 2000), and 1996–2000 (Clark and Yosef 1997, Shirihai et al. 2000). We excluded from the analyses five birds (two identified as female and three as male) because according to the biometrics we consider them to have been sexed incorrectly.

Owing to differences in weather and other local conditions which influence the phenology of migration (median test, $\chi^2 = 294.5$, df = 13, $P < 0.0001$), data were standardized between years. By computing the median date of passage for each year, data were collected. Then the dates of all captured hawks were transformed as values before (minus) or after (plus) the median.

All the basic statistics were performed according to Sokal and Rohlf (1995). We computed correlation between birds' measurements and timing of migration (in Julian dates). However, because in accipiters wing chord is an indicator of body size (e.g., Mueller and Meyer 1985, Wyllie and Newton 1994), we established a condition index. We used a total body-size measurement, which was obtained from the principal component analysis with VARIMAX rotation of four (wing chord, culmen, hallux, and tail length) log-transformed, external measurements (Piersma and Davidson 1991) computed separately for the sexes. All morphometric variables had positive and a similar magnitude of loading on the first component (0.318–0.742, eigen value = 1.811, 45.3% of total variance explained for females and 0.234–0.636; eigen value = 1.577, 39.4% of total variance explained for males) We analyzed structural size (PC1)/mass relationships separately within four age/sex classes to test for allometry or isometry.
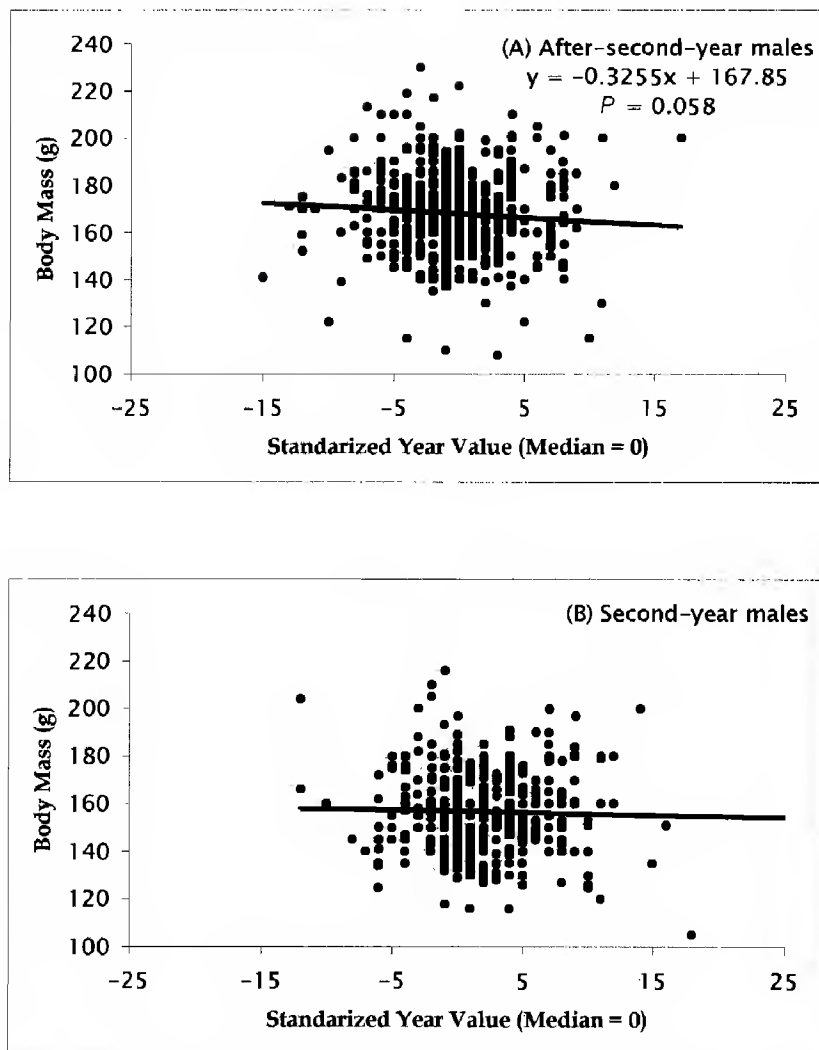
Figure 1. Body mass of (A) after-second-year (ASY) and (B) second-year (SY) male Levant Sparrowhawk in relation to date of capture and passage at Eilat. Regression line is non-significant for SY males.
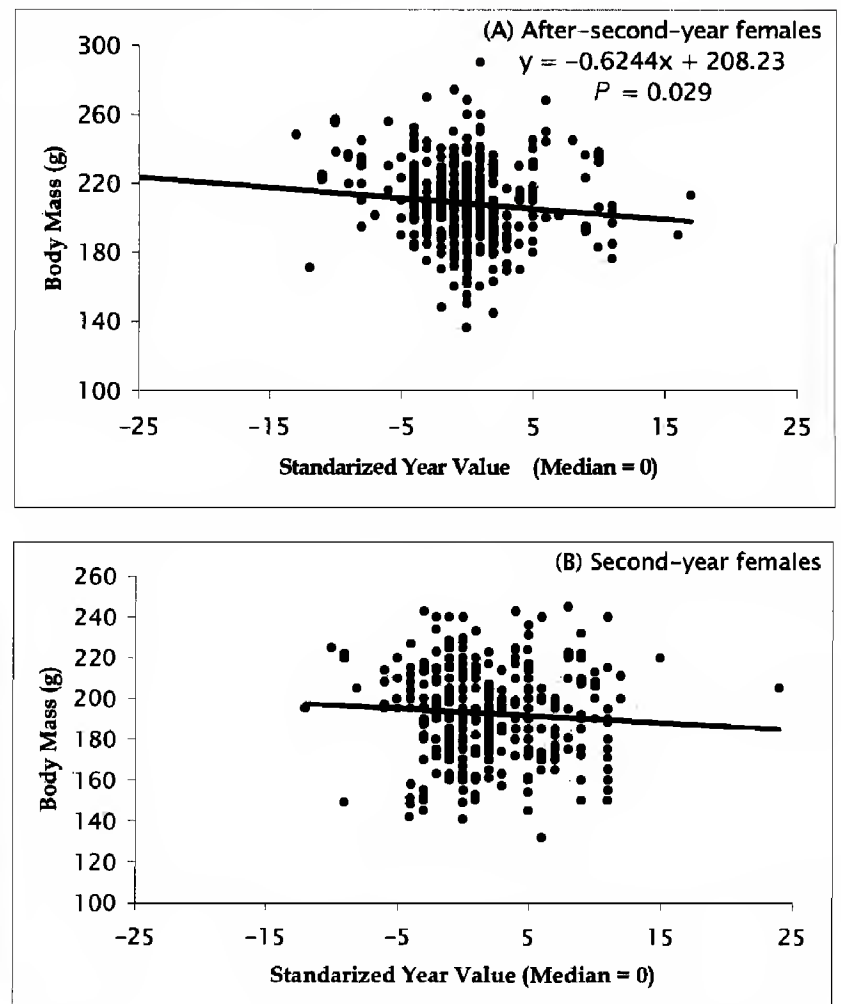

Figure 2. Body mass of (A) after-second-year (ASY) and (B) second-year (SY) female Levant Sparrowhawk in relation to date of capture and passage at Eilat. Regression line is non-significant for SY females.

RESULTS

A total of 1819 migrant Levant Sparrowhawks was captured: 459 in 1984–88, 21 in 1989–95, and 1345 in 1996–2000. Of these, 396 (22%) were adult females, 631 (35%) were adult males, 359 (20%) were juvenile females, and 433 (24%) were juvenile males. Sex ratio among juvenile birds differed significantly from 1:1 ($\chi^2 = 27.4$, $P < 0.0001$), but was not significantly different in adults ($\chi^2 = 3.6$, $P = 0.06$). Hence, sex ratio between the two age categories differed significantly ($\chi^2 = 8.4$, $P = 0.004$).

Each spring, transients were trapped in Eilat between early March and early May. The two sex and two age groups differed significantly in their median time of migration (SY females median date = 27 April, range = 10 March–15 May; ASY females median date = 24 April, 18 March–16 May; SY males, 27 April, 18 March–21 May; ASY males, 25 April, 28 March–12 April; Kruskal-Wallis test, $\chi^2 = 142.36$, df = 3, $P < 0.0001$). A post-hoc Dunn's Q-test ($P < 0.05$) demonstrated that significantly

more ASY individuals of both sex migrate earlier than SY birds.

Wing chord length in males ($r_{1030} = -0.207$, $P < 0.0001$) and females ($r_{744} = -0.127$, $P = 0.001$) changed significantly with date of arrival, as did body mass in males ($r_{1022} = -0.141$, $P < 0.0001$; Fig. 1) and females ($r_{740} = -0.137$, $P < 0.0001$; Fig. 2) changed significantly with date of arrival. Further, a significant correlation was found for both sexes between wing chord length and body mass in spring (males y = 0.140 (±0.011) x + 0.367, $t = 12.61$, $P < 0.0001$ versus females y = 0.128 (±0.011) x + 0.380, $t = 11.17$, $P < 0.0001$). In addition, we found a significant correlation between mass (log transformed before analyses) and wing chord length for juveniles ($r_{1006} = 0.625$, P < 0.0001) and adults ($r_{783} = 0.665$, $P < 0.0001$). However, there was no statistical difference between the correlation values for the two-age classes ($P = 0.152$).

Body mass was also significantly correlated with size obtained from PCA analyses (PC1), both in males: $r_{597} = 0.368$, $P < 0.0001$ and females: $r_{740} =$

Table 1. Analysis of Variance analyses of biometric values of Levant Sparrowhawks related to migration passage at Eilat, Israel.

SOURCE OF VARIATION	SUM OF SQUARES	df	F	P
Covariates	166.525	2	3.978	0.019
Body mass	134.968	1	6.448	0.011
Wing chord	4.626	1	0.221	0.638
Main effects	139.636	2	51.107	<0.001
Age	1755.369	1	83.856	<0.001
Sex	0.147	1	0.007	0.933
2-way interactions				
Age*Sex	30.493	1	1.457	0.228
Explained	3301.656	5	31.545	<0.0001
Residual	37 218.904	1778	20.933	
Total	40 520.560	1783	22.726	

0.330, $P < 0.0001$. We computed also standardized residuals of body mass on PC1. Date of passage was significantly correlated to the standardized residuals, both in males: $r_{598} = -0.154$, $P < 0.0001$ and females: $r_{349} = -0.110$, $P = 0.040$. This suggested, testing for allometry versus isometry, that birds in better than expected 'condition' migrated earlier. Moreover, results from Analysis of Variance revealed that only body mass and age were significantly related to the date of passage (Table 1).

DISCUSSION

In many raptors, adults migrate earlier in spring than do juveniles (Newton 1979, Gorney and Yom-Tov 1994, Yosef et al. 2002). With an overall 10-yr median trapping date of 25 April for adults versus 27 April juveniles, our results, which extend an earlier 5-yr study of Gorney et al. (1999), confirm that Levant Sparrowhawks in Israel, too, exhibit age-related differences in the timing of migration. Although age differences in raptor migration are not completely understood, previous work suggests that such differences occur because breeding pressures on adults select for earlier arrival on the breeding grounds (Newton 1979, Gorney and Yom-Tov 1994), juveniles require more time either to initiate or complete their journeys, or both (Gorney and Yom-Tov 1994, Gorney et al. 1999) or alternatively, juveniles may over-winter farther from their breeding grounds than do adults (Król 1983).

Gorney and Yom-Tov (1994) argued that earlier passage of adult steppe Common Buzzards (*Buteo buteo vulpinus*) at Eilat suggested that adults were

"time selected" migrants, whereas juveniles were "energy-selected" migrants. Because most juvenile birds do not breed, they would not need to reach their "breeding grounds" as early in spring as adults. We offer another explanation: that adults precede juveniles because they are better prepared and more efficient at migration, therefore, are more capable and faster migrants en route. Little is known about the Levant Sparrowhawks on their breeding grounds in Eurasia, and the species has yet to be studied in detail on its wintering grounds in Africa (Shirihai et al. 2000). The fact that adults arrive in Eilat only a few days earlier than juveniles and because adults are heavier than juveniles, in our view, suggests that adults are more capable migrants, rather than that the age classes are using different migration strategies. However, it is also possible that age classes winter in separate regions, at different distances from Eilat, resulting in discrepancy in phenology between the two classes. However, the latter cannot be verified at present owing to the lack of data and observations for the species from the wintering grounds. Another possible explanation is that the different age classes may have different migration strategies because adults have longer wings and tails in the spring (Yosef and Fornasari 2000). Proportionally longer wing and tail length allow for a greater proportion of time spent in soaring flight, which is in contrast to juveniles who have shorter wing and tail which requires comparatively more flapping flight that requires greater fat reserves and better body condition.

Soaring migrants such as Levant Sparrowhawks (Spaar 1997, Spaar et al. 1998) typically travel in large flocks, presumably so that individuals can more quickly locate thermals needed to assist their long-distance movements (Kerlinger 1989). Observations of Broad-winged Hawks (*Buteo platypterus*) in North America suggest that juveniles are more likely to be wind drifted and blown off course than are adults (Hagar 1988, Hoffman and Darrow 1992). It is thought that coastal raptor migrations consist primarily of juveniles of all species because of this fact (Kerlinger 1989). We propose that juvenile Levant Sparrowhawks pass through Eilat later than adults because they are less efficient migrants as shown by their lower body weights and lower 'condition' (Clark and Yosef 1997, Gorney et al. 1999).

Although Gorney et al. (1999) found no significant associations between condition indices of

adults and juveniles, we believe that large numbers of Levant Sparrowhawks, particularly immatures, reach Eilat in poor body condition. Many raptors ringed at Eilat have tar and oil residues on their feathers and feet (Clark and Gorney 1987). Perhaps they mistakenly land in oil fields of the Sahara and Sinai deserts in search of fresh water during migration flights (Clark and Gorney 1987). Data collected from 1996–2000 indicate that 81% (N = 43) of oil-contaminated Levant Sparrowhawks were juveniles. We assume that juveniles are more stressed during migration, and therefore, more likely to seek drinking water.

Gorney et al. (1999) found no significant associations within age and sex groups between date of migration and physical condition. In contrast, our study shows that birds with longer wing chords and greater body mass passed through the area earlier than smaller individuals of the same sex and age class. In this study, we find that wing chord was significantly correlated with body mass, suggesting that while on migration, larger birds are heavier. Gorney and Yom-Tov (1994) suggest that the large proportion of immatures ringed at Eilat may have resulted from age differences in migration routes as has been reported for other raptor species (Bildstein et al. 1983, Yosef 1996b, Yosef and Alon 1997). No evidence suggests that adult Levant Sparrowhawks follow a different migration route than juveniles (Shirihai and Christie 1992, Shirihai 1996, Shirihai et al. 2000). Rather, geography of the region (Shirihai et al. 2000, Zalles and Bildstein 2000) suggests that northern end of the Gulf of Eilat serves as a concentration point for many western Palearctic migrating raptor species during spring, regardless of age or sex (Spaar et al. 1998). We think that the limited sample size included by Gorney and Yom-Tov (1994) and Gorney et al. (1999) in their study may have led them to conclusions not supported by our data set, which includes more than double in the number of birds involved in the previous analyses.

In conclusion, the fact that within sex and age classes, heavier and better 'condition' individuals are trapped early in the season suggests that in both juveniles and adults, the more efficient migrants pass earlier than less efficient migrants, and that adults are more efficient than juveniles.

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VOCAL DEVELOPMENT IN AMERICAN KESTREL (*FALCO SPARVERIUS*) NESTLINGS

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ABSTRACT.—We studied the acoustical characteristics of calls made by nestling American Kestrels (*Falco sparverius*). A total of 563 vocal samples was obtained from 88 chicks (49 males and 39 females) from 20 broods. Thirteen frequency, three numerical, and two temporal characteristics were measured using audio spectrography. Discriminant function analysis failed to distinguish the calls of male and female chicks, but univariate and principal component analyses suggest that vocal ontogeny proceeds more rapidly in males than in females. The acoustical characteristics of call notes changed in a consistent manner as nestlings matured, and by day 16 chicks produced calls similar to those of adults.

KEY WORDS: *American Kestrel; Falco sparverius; vocalization; development.*

DESARROLLO VOCAL EN POLLUELOS DEL CERNICALO (*Falco sparverius*)

RESUMEN.—Estudiamos las características acústicas de las vocalizaciones hechas por polluelos de cernícalo (*Falco sparverius*). Un total de 563 muestras de vocalizaciones fueron obtenidas de 88 pollos(49 machos y 39 hembras)de 20 nidadas. Trece características de frecuencia, tres numéricas y dos temporales fueron medidas usando audio espectrografía. El análisis de la función discriminante falló para distinguir los llamados de los pollos hembras y machos, pero el análisis univariado y de componentes principales sugiere que la ontogenia vocal procede mas rápidamente en machos que en hembras. Las características acústicas de las notas de los llamados, cambiaron de manera consistente con la madurez de los polluelos, y para el día 16 los pollos produjeron llamados similares a los de los adultos.

[Traducción de César Márquez]

Although the acquisition of species-specific song has been studied extensively in passerines (e.g., Kroodsma and Miller 1982), much less is known about the development of vocal behavior in non-passerines. The American Kestrel (*Falco sparverius*) has a simple vocal repertoire, consisting of three main calls in adults: *klee, whine,* and *chitter,* and combinations thereof (Willoughby and Cade 1964). Vocalizations of nestlings have been described (Sherman 1913, Roest 1957, Balgooyen 1976, Smallwood and Bird 2002), but only qualitatively. Audio spectrography facilitates quantification of acoustical signals, and the variables derived from spectrographs may be analyzed with both univariate and multivariate statistical treatments. For example, discriminant function analysis was used to distinguish calls among four species of penguins (Thumser et al. 1996) and principal component analysis was used to identify individuals within a flock of Greater Flamingos (*Phoenicopterus ruber,* Mathevon 1997). Multivariate techniques also have been used to determine gender in birds whose vocalizations are not readily discernable by human observers (e.g., Whooping Cranes, *Grus americana;* Carlson and Trost 1992). No differences in vocalizations of male and female American Kestrels, either adults or young, have been reported. The objectives of this study were to analyze acoustical characteristics of calls made by nestling kestrels to (1) determine if gender can be distinguished vocally and (2) examine ontogenic changes.

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Table 1. Principal component analysis for frequency variables used to describe acoustical characteristics of nestling American Kestrel calls. See methods for descriptions of variables.

VARIABLE	EIGENVECTORS	
	PC1	PC2
Low mean frequency	0.357	−0.150
End mean frequency	0.340	−0.161
End maximum frequency	0.322	−0.194
Low maximum frequency	0.316	−0.207
Dominant harmonic	0.306	−0.115
Maximum frequency	0.300	−0.010
High mean frequency	0.283	0.335
High maximum frequency	0.270	0.347
Initial mean frequency	0.256	0.210
Low 25% frequency	0.238	−0.304
High 75% frequency	0.220	0.373
Initial maximum frequency	0.213	0.218
Frequency range	−0.044	0.549

Table 2. Age-related changes in acoustical characteristics of American Kestrel chicks (49 males and 39 females pooled) from northwestern New Jersey, 1999. For each variable, the correlation is between age category ($N =$ 11, 0–1 d through 20–21 d) and the mean value for each age category. See methods for descriptions of variables.

VARIABLE	r_s	P
Notes/call	0.964	0.0001
Internote	−0.973	0.0001
Note length	0.916	0.0001
Number of harmonics	0.973	0.0001
Dominant harmonic	0.954	0.0001
Amplitude pulses	−0.706	0.0152
Maximum frequency	0.927	0.0001
Initial maximum frequency	0.891	0.0002
High maximum frequency	0.845	0.0010
Low maximum frequency	0.973	0.0001
End maximum frequency	0.936	0.0001
Initial mean frequency	0.900	0.0002
High mean frequency	0.855	0.0008
Low mean frequency	0.964	0.0001
End mean frequency	0.927	0.0001
High 75% frequency	0.827	0.0017
Low 25% frequency	0.882	0.0003
Frequency range	−0.809	0.0026

STUDY AREA

The study area was in rural northwestern New Jersey, bordered to the north and west by the Kittatinny Ridge and Delaware River, and to the east and south by residential and commercial development. This area is characterized by mixed agriculture, including corn, hay, and cattle production, and forestland in the ridge and valley physiographic region (Sauer et al. 1997). Eighty-two wooden nest boxes (internal dimensions: 20 × 23 cm floor, ca. 34 cm in height) were erected in open habitats in Sussex County (centered ca. 41°11′N, 74°38′W) between 1 April 1995 and 6 April 1999, and 103 nest boxes in Warren County (ca. 40°47′N, 75°04′W) between 5 August 1995 and 19 April 1998; 124 nest boxes were available during the 1999 breeding season.

METHODS

Data Collection. We monitored nest boxes for kestrel breeding activity at 21–28-d intervals between 30 March and 3 August 1999. Once a nest box contained at least one kestrel egg, additional visits were scheduled so that chicks would be observed within 2 d of hatching. Age was determined by body mass (Roest 1957, Balgooyen 1976, Lacombe et al. 1994, Smallwood and Bird 2002); eight chicks were still wet when first observed. To collect vocal samples, we visited nest boxes with chicks at 2–3-d intervals until the oldest chick of a brood was about 22 d old. In this study, area chicks fledge on about day 28 and are prone to premature fledging if disturbed during the preceding week (Smallwood and Natale 1998).

We made analog audio recordings with a Marantz PMD 101 portable cassette recorder. To collect vocal samples, we removed all chicks of a brood from their nest box and held each (one at a time) by hand in an upright position ca 12 cm from the recorder's built-in condenser microphone. Most chicks vocalized within a few seconds. If a chick failed to vocalize for 3 min, we ended the recording

attempt and noted that the chick was silent. We identified individual chicks by coloring the down feathers of the humeral tract with permanent marking pens; gender was determined when primary feathers erupted, about day 8.

The analog recordings were digitized at a 44.1-kHz sampling rate using the sound recorder program of MicroSoft Windows 98 on a PC platform. We prepared digital spectrographs with Avisoft-SASLab Pro v. 3.4 software with an effective bandwidth of 647 Hz and a 256-point Fast Fourier Transform (FFT) size. Analytical features of this program include amplitude spectra of user-defined segments of the acoustical signals.

Acoustical Variables. All vocalizations consisted of a series of distinct notes that ranged from about 10–300 msec in duration. We defined a "call" operationally as a sequence of notes such that the interval between notes of sequential calls was at least 1.5 times greater than the interval between notes within a call; the "intercall" durations generally were at least several times greater than the "intracall" durations. We measured the following 18 acoustical variables. (1) NOTES/CALL: the mean number of notes per call. A random numbers table was then used to select one note (excluding the last note of a call; see next variable) from each vocal sample for acoustical analysis. (2) INTERNOTE: the interval (in sec) between the selected note and the following note within the same call. (3) NOTE LENGTH: the duration (in sec) of the selected note. (4) NUMBER OF HARMONICS: We examined a spectrograph of the selected note for distinct frequency bands. We then analyzed the note at the point in time when the maximum number of frequency bands
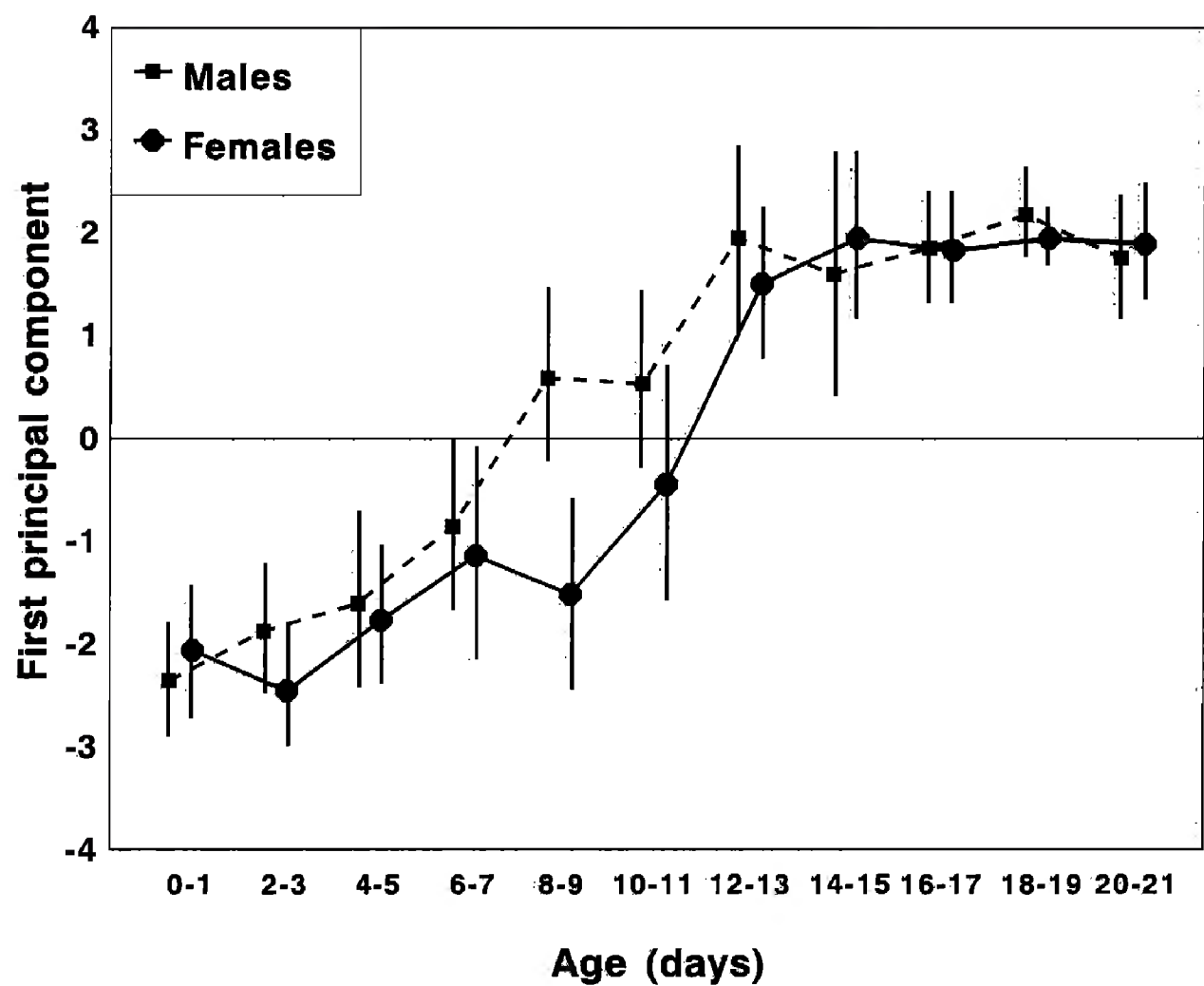
Figure 1. Vocal development of male (N = 38) and female (N = 31) American Kestrel chicks, northwestern New Jersey, 1999. Values are means ($\pm$SE) of the first principal component. Principal component analysis was performed on 13 frequency variables; PC1 eigenvectors for these variables are presented in Table 1.
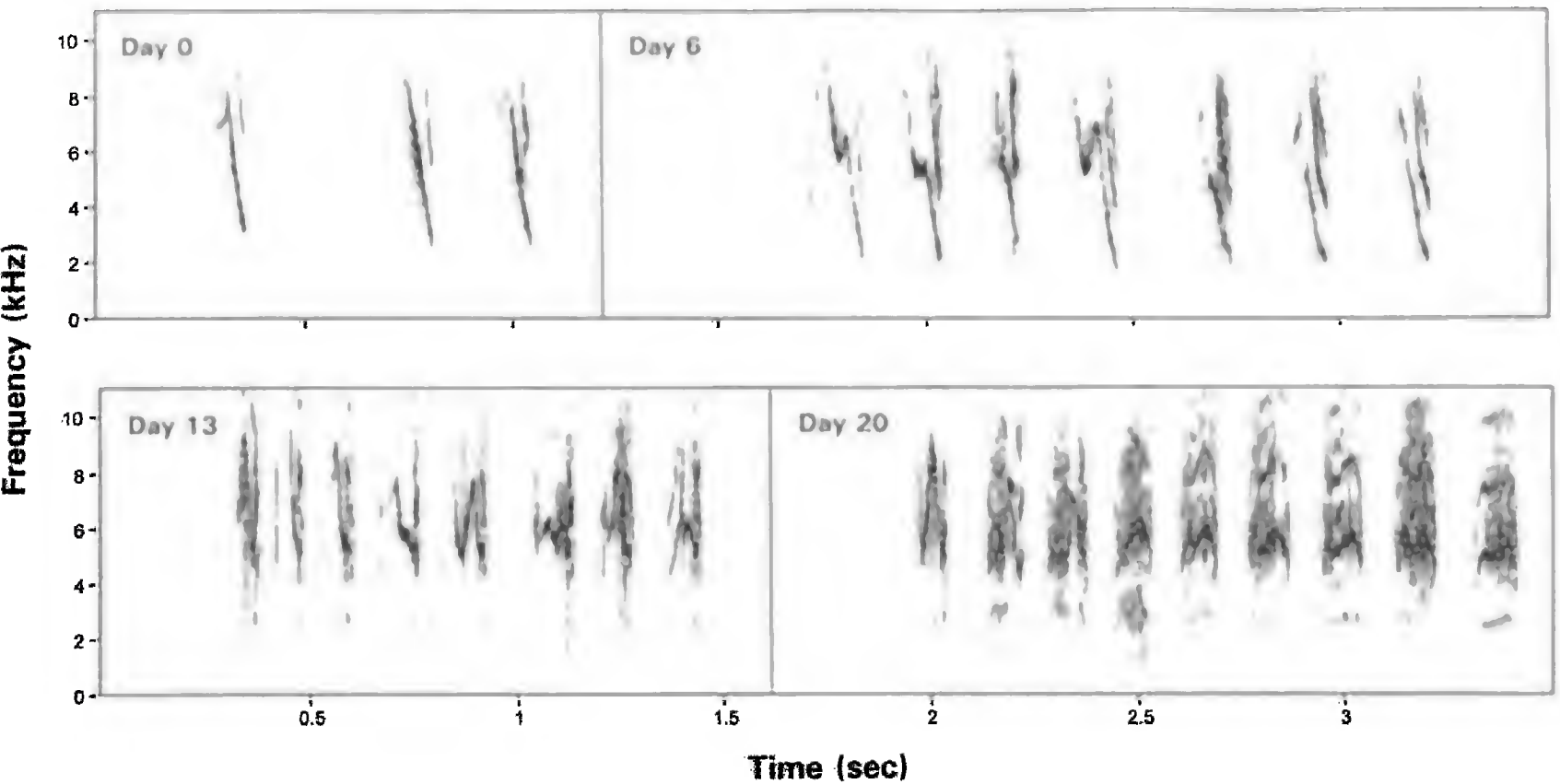

Figure 2. Age-related changes in the calls of an individual male American Kestrel chick from Sussex County, New Jersey, 1–21 June 1999. Digital spectrographs of analog recordings were prepared using 44.1-kHz sampling rate and Avisoft-SASLab Pro v. 3.4 software (with an effective bandwidth of 647 Hz and a 256-point FFT transform size). Amplitude is indicated by darkness (i.e., black indicates more energy than grey).
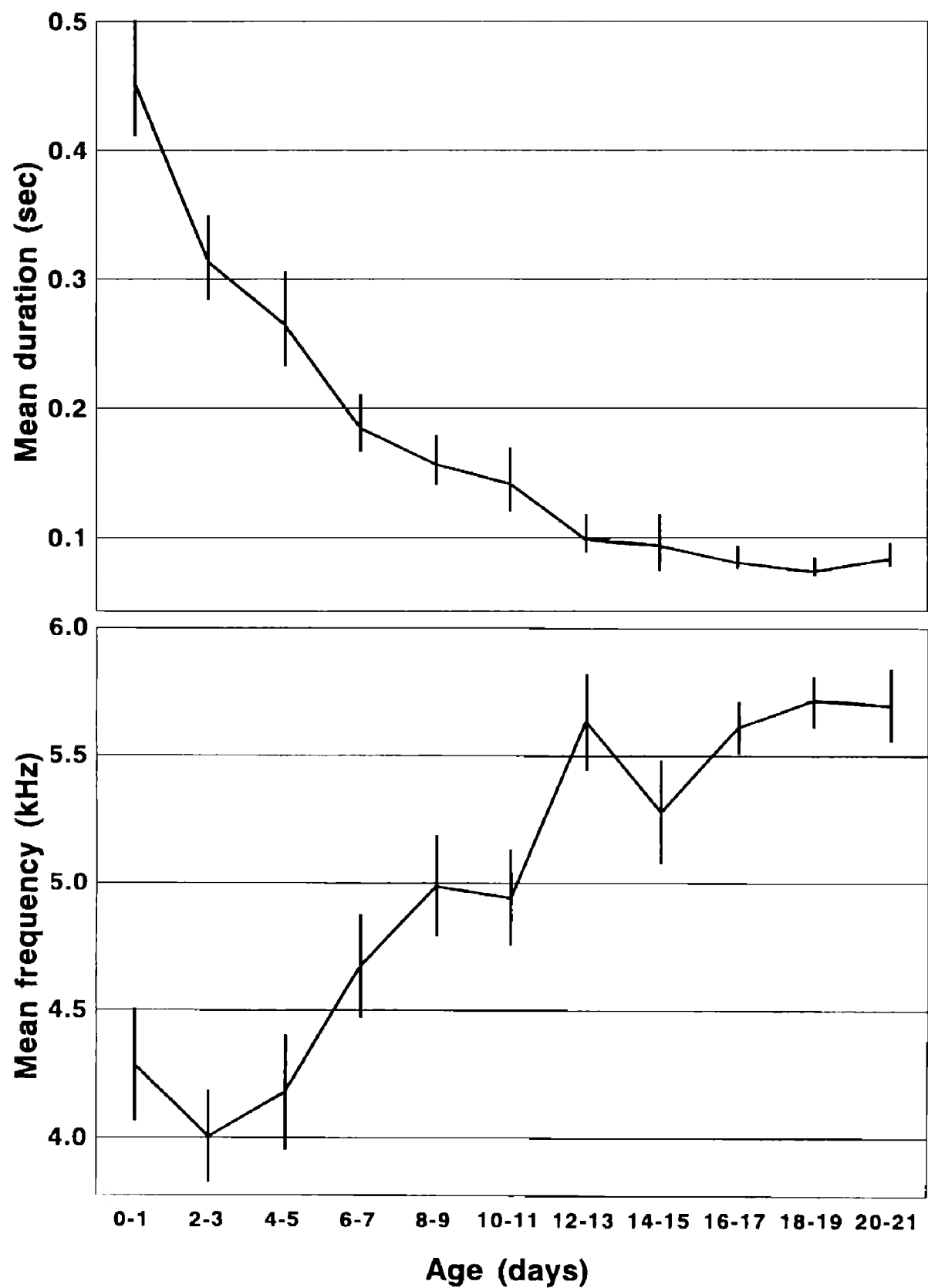
Figure 3. Call notes of American Kestrel chicks ($N = 69$), northwestern New Jersey, 1999. (Top) Call notes are given with increasing rapidity during the nestling stage. Values are means ($\pm$SE) of internote durations. (Bottom) The frequency (pitch) of call notes increases during the nestling stage. Values are the frequencies (mean $\pm$SE) that have the highest amplitude within a call note.

were separated by the greatest differences in amplitude. (5) DOMINANT HARMONIC: the frequency (in kHz) of the harmonic with the greatest amplitude. (6) AMPLITUDE PULSES: the number of distinct amplitude pulses within the selected note. (7) MAXIMUM FREQUENCY: the frequency with the highest amplitude, measured from the cumulative amplitude spectrum generated from the entire selected note. We measured the remaining variables from the spectrograph, in which curves were generated denoting specific properties of the

signal for each point in time within the selected note. (8) INITIAL MAXIMUM FREQUENCY: the frequency that had the maximum amplitude at the start of the note. (9) HIGH MAXIMUM FREQUENCY: the highest frequency on the maximum amplitude curve within the selected note. (10) LOW MAXIMUM FREQUENCY: the lowest frequency on the maximum amplitude curve within the selected note. (11) END MAXIMUM FREQUENCY: the frequency that had the maximum amplitude at the end of the note. (12) INITIAL MEAN FREQUENCY: the
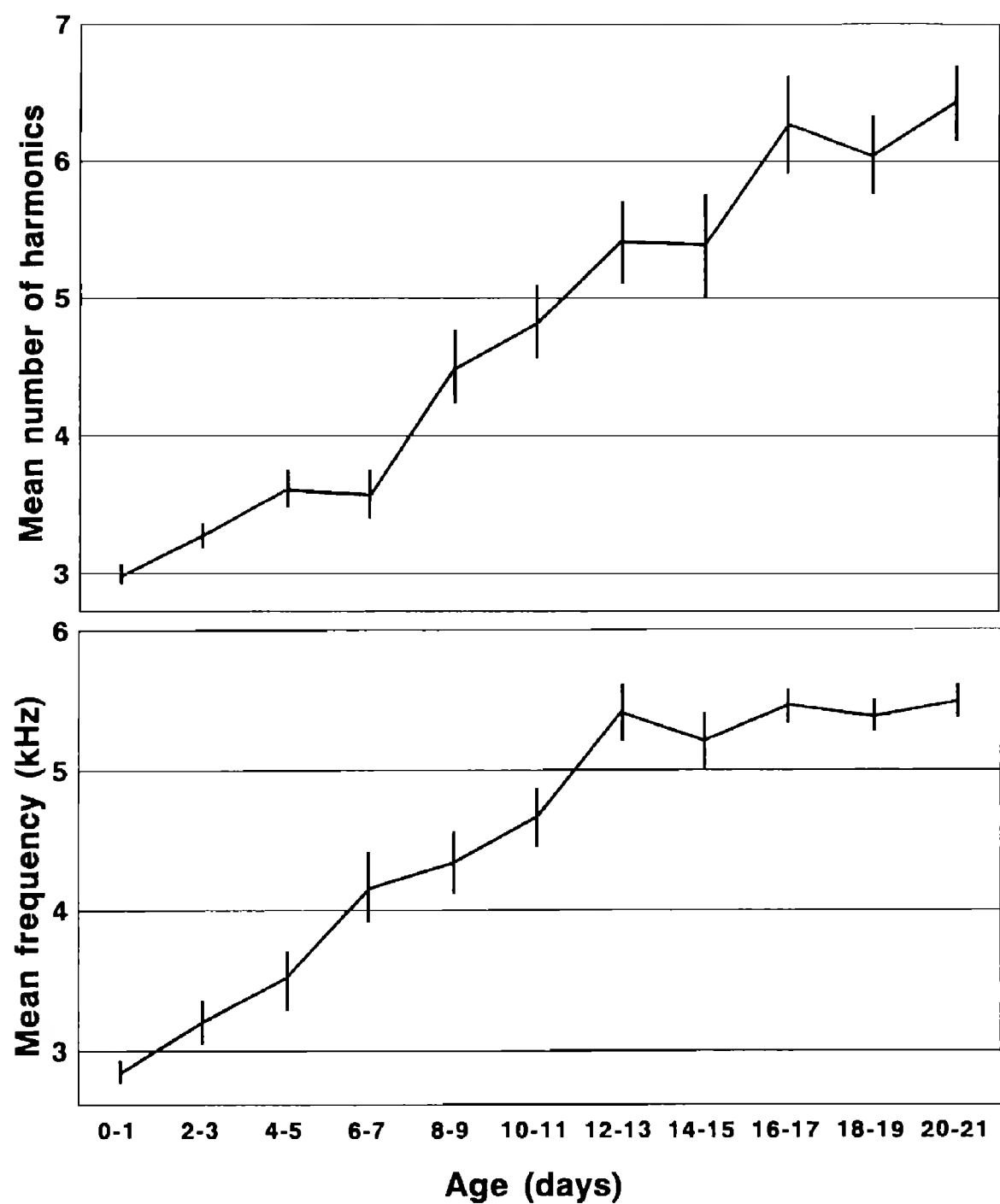
Figure 4. Call notes of American Kestrel chicks ($N = 69$) from northwestern New Jersey, 1999. (Top) The number of distinct harmonic frequencies increases during the nestling stage. Values are means $\pm$SE. (Bottom) The frequency (pitch) of the dominant harmonic increases during the nestling stage. Values are the frequencies (mean $\pm$SE) of the harmonic that has the highest amplitude within a call note.

mean frequency at the start of the note. (13) HIGH MEAN FREQUENCY: the highest frequency on the mean frequency curve within the selected note. (14) LOW MEAN FREQUENCY: the lowest frequency on the mean frequency curve within the selected note. (15) END MEAN FREQUENCY: the mean frequency at the end of the note. (16) HIGH 75% FREQUENCY: the highest frequency on the 75th percentile curve within the selected note. The 75th percentile curve denotes, for each point in time, the frequency below which 75% of the acoustical energy is present. This variable, and the next two variables, provide measures of frequency ranges that are not dependent upon recording level. (17) LOW 25% FREQUENCY: the lowest frequency on the 25th percentile curve within the selected note. (18) FREQUENCY RANGE: an index of frequency range, 75% HIGH FREQUENCY minus 25% LOW FREQUENCY.

Statistical Analyses. We divided the data set into 11 2-

d age categories, allowing each age category to be examined separately and ensuring that no individual kestrel was represented by more than one vocal sample per age category. The data were tested for normality. Because we detected significant deviations, we used nonparametric statistical treatments for all univariate comparisons between males and females. The results of comparisons of gender within one age category were not independent of the comparisons within another age category because the same individual birds were represented in each, therefore, we adjusted the P-values using Bonferroni's probabilities (Snedecor and Cochran 1980). We performed a discriminant function analysis, with gender as the single classification variable, separately for each age category. The 13 acoustical variables denoting frequency (measurements in kHz) were subjected to a principal component analysis, and we employed univariate treatments to compare males and females with respect to the

first two principal components separately for each of the 11 age categories; again, we adjusted the P-values due to the nonindependence of these tests. Finally, we tested age-related changes in the acoustical properties of vocalizations with nonparametric correlation analyses; age category ($N = 11$) was correlated with the mean values (of each age category) for each variable.

RESULTS

Gender Comparisons. A total of 563 vocal samples was obtained from 88 chicks (49 males and 39 females) from 20 broods. We sampled individual chicks from 1–9 times ($\bar{x} = 6.4$, mode = 8). The tendency to vocalize was similar for males and females; mean response rates were 89.8% ± 2.17 (SE) and 90.2% ± 2.46, respectively ($Z = 0.374$, $P = 0.71$, Wilcoxon rank sums test).

Univariate analysis of the 18 acoustical variables (for 11 age categories; 198 comparisons in all) revealed three significant differences between males and females, all for age 8–9 d: INITIAL MEAN FREQUENCY ($\bar{x} = 5.26$ kHz ± 0.20 and 4.35 kHz ± 0.24, respectively, $Z = 2.865$, $P = 0.046$, Wilcoxon rank sums test), LOW 25% FREQUENCY ($\bar{x} = 3.69$ kHz ± 0.34 and 2.78 kHz ± 0.24, respectively, $Z = 2.896$, $P = 0.042$), and DOMINANT HARMONIC ($\bar{x} = 5.08$ kHz ± 0.28 and 3.59 kHz ± 0.30, respectively, $Z = 3.330$, $P = 0.010$).

The discriminant function analyses for each age category had error rates that ranged from 7.9% (age 14–15 d, 1 of 11 females classified as a male and 1 of 15 males classified as a female) to 37.4% (age 20–21 d, 10 of 25 females classified as males and 8 of 15 males classified females). The error rate was not correlated with age category ($r_S = -0.109$, $P = 0.75$). Pooled results of the 11 age-specific analyses had an error rate of 26.0% (63 of 249 samples from females classified as males and 79 of 297 samples from males classified as females).

A principal component analysis of the 13 acoustical variables denoting frequency generated a first principal component (PC1) that accounted for 50.03% of the sample variability (eigenvalue = 6 504) and a second principal component (PC2) that accounted for an additional 17.92% of the sample variability (eigenvalue = 2.329); thus, over two-thirds of the sample variability was explained by the first two principal components (Table 1). Univariate analysis of PC1 and PC2 for 11 age categories (22 comparisons in all) revealed only one significant difference between males and females:

for age 8–9 d, mean PC1 values were 0.58 ± 0.42 and −1.52 ± 0.48, respectively ($Z = 3.083$, $P = 0.022$, Wilcoxon rank sums test; Fig. 1).

Age Comparisons. Figure 2 is a composite spectrograph of the vocalizations of an individual male kestrel chick at ages 0, 6, 13, and 20 d. The day 0 call notes were "thin" (harmonically simple, with a narrow frequency range at any point in time), clear tones that dropped in pitch, sounding like *peep* or *cheep*. The day 6 call notes were given more rapidly and had more energy in the upper frequencies. The pitch was slurred downward and the notes were more *cheep*-like. The day 13 call notes were delivered faster still and had more energy concentrated into distinct harmonic frequencies. The pitch, no longer slurred downward, instead was either steady or tremulous, sounding like *chee* or *kee*. The day 20 call was similar to that of an adult *klee*. Distinct harmonic frequencies were well developed and the frequency modulation, although distinct in the spectrograph, was rapid and slight, such that the notes did not sound particularly tremulous.

Each acoustical variable was significantly correlated with age category (Table 2). All correlations were positive, except for INTERNOTE, AMPLITUDE PULSES, and FREQUENCY RANGE. The relationship between age category and INTERNOTE, MAXIMUM FREQUENCY, NUMBER OF HARMONICS, and a DOMINANT HARMONIC are given in Figs. 3 and 4.

DISCUSSION

Acoustical characteristics of call notes changed in a consistent manner as chicks matured. Notes became longer and increasingly complex with respect to harmonic structure, and both the number of notes per call and the rate at which they were delivered increased. In general, vocal characteristics changed most rapidly during the first two weeks (Figs. 1, 3, and 4). By about day 16 chicks were able to produce calls that sounded similar to the *klee* calls of adults. Roest (1957) noted that chicks of this age were able to utter the adult-like "*killy-killy*" cry, although some chicks were silent when handled.

The discriminant function analyses did not perform well in distinguishing gender. The pooled error rate of 26.0% was slightly closer to that of random classification (50% error) than to perfect discrimination. Vocalizations of males and females were essentially indistinguishable from each other

with respect to the acoustical characteristics we measured, except that males appeared to progress toward adult-like vocalizations more rapidly than females, especially during the second week (Fig. 1). The first principal component (derived from frequency variables and most strongly influenced by LOW MEAN FREQUENCY, END MEAN FREQUENCY, and END MAXIMUM FREQUENCY; Table 1) differed significantly between 8–9-d-old males and females. Three other frequency variables (INITIAL MEAN FREQUENCY, LOW 25% FREQUENCY, and DOMINANT HARMONIC) also differed significantly at this age. These results suggest that males may develop adult-like frequencies (higher pitch; Table 2) sooner than females.

Although possible, it is unclear if individual variability in vocalization patterns is sufficient for individual recognition by kestrels. Such vocal recognition is widespread in both passerines and nonpasserines (e.g., Falls 1982, Stoddard 1996, and citations therein). Additional research is required to document if this behavior occurs in American Kestrels.

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MORPHOMETRICS AND STATUS OF AYRES'S HAWK-EAGLE IN ZIMBABWE

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ABSTRACT.—We recorded information on plumage, molt, body mass, and morphology for 28 Ayres's Hawk-Eagles (*Hieraaetus ayresii*); 17 were trapped or injured in Zimbabwe between 1981–2002, the other 11 were museum specimens. Juvenile and adult birds had variable plumage coloration. Some adults of either sex had a black eye mask and others a pied appearance (a white eyebrow mark over black eye mask), while all juveniles had a pale eyebrow mark over a slate eye mask. Adult females were more heavily marked than adult males. Ayres's Hawk- Eagles in captivity started molt in August–September ($N = 2$, 13 molts) and changed into adult plumage at the end of their molt at 2 yr of age. The mean body mass for males was 656.2 g ($N = 8$) and for females 1003.0 g ($N = 20$). Body mass and wing length did not overlap between sexes. Of nine nests, six were on well-wooded hill slopes and three were in riparian woodland. Nests were 9–15 m above ground, situated below the canopy and nest diameters were 71–129 mm. Although Ayres's Hawk-Eagle is a rare species, it was not as scarce in Zimbabwe as some observers had claimed.

KEY WORDS: *Ayres's Hawk-Eagle; Hieraaetus ayresii; breeding; capture; morphology; plumage; status; Zimbabwe.*

MORFOMETRÍA Y ESTADO DEL ÁGUILA DE AYRES EN ZIMBABWE

RESUMEN.—Colectamos información sobre el plumaje, muda, masa corporal y morfología de 28 águilas de Ayres (*Hieraaetus ayresii*); 17 fueron atrapadas o heridas en Zimbawe entre 1981–2002, y las otras once fueron especimenes de museo. Las aves juveniles y las adultas tuvieron coloración de plumaje variable. Algunos adultos de ambos sexos tenían una mascara con un ojo negro y otros una apariencia moteada (una marca de ceja blanca sobre la mascara de ojo negro), mientras que todos los juveniles tuvieron una pálida marca de ceja sobre una mascara de ojo pizarra. Las hembras adultas estaban mas fuertemente marcadas que los machos adultos. Las águilas de Ayres en cautividad inician su muda en Agosto–Septiembre ($N = 2$, 13 mudas) y viran hacia su plumaje de adultos al final de su muda en el 2 año de edad. La masa corporal promedio para los machos fue 656.2 g ($N = 8$) y para las hembras 1003.0 g ($N = 20$). La masa corporal y la longitud del ala entre sexos no se sobrelapo entre sexos. De nueve nidos, seis estuvieron en pendientes de colinas bien arboladas y tres en bosques riparios. Los nidos estaban entre 9–15 m sobre el piso, situados bajo el dosel y con diámetros entre 71–129 mm. Aunque el águila de Ayres es una especie rara, esta no era tan escasa como algunos observadores han afirmado.

[Traducción de César Márquez]

Ayres's Hawk-Eagle (*Hieraaetus ayresii*), is a small, dashing raptor that is thought to be inexplicably rare throughout its range (Brown et al. 1982, del Hoyo et al. 1994, Harrison et al. 1997). We follow Amadon and Bull (1988) in using the specific name *ayresii* for this eagle. Little is known about this species (Steyn 1982, Harrison et al. 1997, Virani and Watson 1998), other than some basic description of its breeding biology, which has been reported in Kenya (Brown 1966, Dewhurst et al. 1988). Ayres's Hawk-Eagles may occur in urban areas where they commonly prey on Rock Doves *(Columba livia;* Irwin 1981, 1985, del Hoyo et al. 1994, Harrison et al. 1997), other columbids, and small birds (Lendrum 1982, Dewhurst et al. 1988). It is an aerial hunter and may spend much of the day on the wing (Clark 1999). Few nests have been found anywhere, and there are only 12 breeding

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Table 1. Body mass (g) and measurements (mm) of Ayres's Hawk-Eagles.

		MALES				FEMALES			
	AGE	MEAN	RANGE	SD	N	MEAN	RANGE	SD	N
Mass	Juvenile	650.0	620–680	±22.36	4	988.5	950–1045	±38.74	10
	Adult	662.5	615–714	±37.94	4	1017.5	879–1150	±87.02	10
Wing	Juvenile	355.0	340–368	±10.0	8	396.7	374–420	±13.67	19
	Adult	346.0	320–360	±14.97	5	392.8	375–408	±11.17	16
Tail	Juvenile	189.4	180–198	±6.0	8	208.4	191–224	±10.3	18
	Adult	185.2	175–195	±7.29	4	210.6	196–225	±8.96	17
Tarsus	All	63.5	61–67	±2.02	13	73.8	61–80	±4.97	19
Toe	All	45.2	42–49	±1.8	12	52.0	46–56	±2.6	17
Bill	All	21.3	20–22	±1.0	9	25.4	24–31	±5.78	12
Gape	All	25.3	24–28	±1.3	12	27.9	25–32	±1.96	12

records for Zimbabwe (Irwin 1981), some of which may be questionable. There are few data on measurements and body mass (Maclean 1993), and no details on the progression of juvenal to adult plumage (Brown et al. 1982, Steyn 1982). Plumage is variable, and includes primarily light and uniformly dark color morphs (Brown 1966, Brown and Davey 1978, del Hoyo et al. 1994, Kemp and Kemp 1998), but there are few data summarizing this variation. Furthermore, it is likely that plumage variation and confusion with species such as African Hawk-Eagle (*H. spilogaster*), Booted Eagle (*H. pennatus*), and Cassin's Hawk-Eagle (*Spizaetus africanus*) have led to the Ayres's Hawk-Eagle being overlooked throughout its range (Brown 1966, Ash 1981, Clark 1999).

Here, we present new data on plumage (including molt), change of eye color, morphology, and body mass of Ayres's Hawk-Eagles in Zimbabwe. We also summarize sightings and breeding records in Zimbabwe and discuss the status of Ayres's Hawk-Eagle.

METHODS

Nine Ayres's Hawk-Eagles were captured and another eight eagles were recovered injured in Zimbabwe. Fifteen of these were weighed and 16 measured (Table 1). Mass measurement was done to the nearest 5 g. Other measurements follow Biggs et al. (1978), except for bill, which was taken as the chord from tip of bill to distal edge of the fleshy cere. Vernier calipers accurate to 0.5 mm were used to measure bill, gape, tarsus, and middle toe. Wing and tail length were measured with a wing rule accurate to 1 mm. Wing area, wing span, and mass loading follow Mendelsohn et al. (1989). The scientific literature was searched for further data (Brown and Davey 1978, Hartley 1982, Dewhurst et al. 1988, Grimes 1987, Hanmer 1997) and 11 museum specimens in the collection of the Natural History Museum of Zimbabwe

(NHMZ) were examined and measured. We also introduced data (including mensural) on five specimens from South Africa provided by A.C. Kemp, and one from Zimbabwe (Transvaal Museum, TM), and 10 from the British Museum (BM). Birds were sexed on the basis of size (Table 1), males being considered the smaller birds, less than 750 g body mass and 370 mm wing length, respectively. Body mass and wing length between sexes were nonoverlapping. Where body mass was not available and wing length was close to 370 mm, measurements of tarsus (<67 mm for male) and mid-toe (<49 mm for male) were also taken into consideration.

An eagle in its juvenal plumage was classed as juvenile and as an adult after its first prebasic 1 molt (Humphrey and Parkes 1959) was completed. Eye color, plumage, and molt descriptions include the progress of two individuals in captivity from juvenile to adult. R. Hartley has kept two male and two female Ayres's Hawk- Eagles for extended periods, including a male for five and a female for ten years. Our own records of sightings were included with those of the Zimbabwe Falconers' Club (ZFC, Hartley 1993). Breeding records were provided by egg collectors and falconers. Laying dates were estimated on the basis of 45 d and 75 d for incubation and nestling periods, respectively (Steyn 1982).

RESULTS

Captures and Specimens. Of 23 eagles recovered in Zimbabwe, four in South Africa, one in Zambia, and one in Kenya, 18 were juveniles (shot = 4, collisions = 5, captured = 9) and 11 were adults (shot = 5, collisions = 2, captured = 4). One female was recovered at Kalichero in northern Zambia after fighting with a European Honey Buzzard (*Pernis apivorus*) (Benson 1962). In Zimbabwe seven eagles were involved in collisions: two with vehicles, one with a power line, and four struck fences. Five eagles were captured at pigeon lofts in towns and another five were captured on farm lands just north of Harare. A juvenile male (620 g)
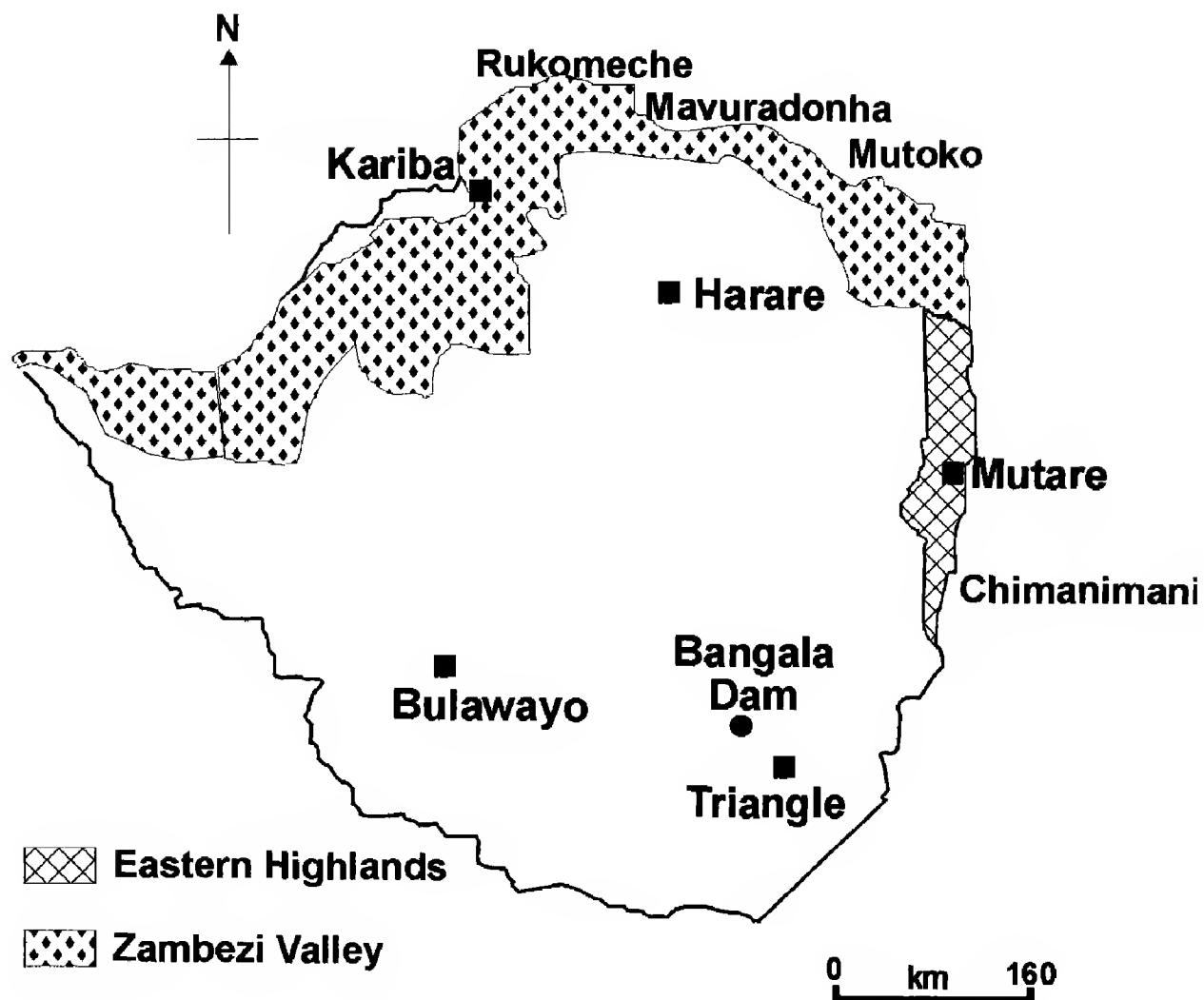
Figure 1.   Locations of places mentioned in the text in Zimbabwe.

was captured after it attacked a tethered adult fe-
male Black Sparrowhawk (*Accipiter melanoleucus*,
920 g), the latter holding onto the eagle. One fe-
male was recovered in a chicken pen at Bulawayo
(Hartley 1982; Fig. 1). Eight eagles were males (two
adults and six juveniles) and 12 were females (two
adults and 10 juveniles). Ten of these eagles were
released. Six of the specimens in the NHMZ were
from Zambia and one was from South Africa.

While most eagles were seen singly, sometimes
they occurred in small groups. Two juveniles (male
and female) were trapped in the company of pairs
of adults in Harare and Bulawayo, but breeding has
not yet been recorded in these towns. A juvenile
female was trapped within an hour of trapping an
adult male (March) near Harare, and two juvenile
females were trapped (April) about an hour apart
in the same general area. A juvenile male was seen
with an adult (unknown sex) at a loft in Harare
(January) and at Triangle (February). As Ayres's
Hawk-Eagle lays mainly in April–May, these juve-
niles may have been independent of the adults.

Body Mass and Measurements. Based on body
mass and wing length, one museum specimen was
incorrectly sexed, while 10 records that were un-

sexed were now classified accordingly. The wing
loading and wingspan of a juvenile male (Table 1)
was 0.387 g/cm^2 (total wing area = 1652.67 cm^2)
and 97 cm, respectively. These measurements were
90% and 78% of that recorded for females by Men-
delsohn et al. (1989).

Plumage. There was substantial variation within
the juvenile and adult morphs, both between and
within sexes (Tables 2 and 3; see photographs in
Oberprieler and Cillie 2002). All juveniles and
adults had an eye mask (Fig. 2). Juveniles had a
pale eyebrow over a slate eye mask. Juveniles had
either cream, buff or rufous nape feathers, which
were streaked with dark brown or slate as stated by
Brown et al. (1982). While the dark brown to slate
throat and/or chest streaks extended over the
shoulders like two shoulder straps in most (Hartley
1982), some individuals had almost plain colored
underparts from throat to abdomen; the degree of
streaking and/or blotching on the chest was not
related to sex. The underwing coverts were cream,
buff or rufous. The upper-wing coverts, back and
rump were edged paler, giving a scaled appearance
(Brown et al. 1982) that is most pronounced in the

Table 2. Plumage of juvenile Ayres's Hawk-Eagles.

EAGLES	CROWN	HEAD		EYE MASK	THROAT/CROP/CHEST/BELLY
		FOREHEAD/ EYEBROW			
Males					
$N = 2$	light brown	light brown		slate	light brown with slate streaks on flanks
$N = 3$	slate	cream		slate	cream-buff with slate streaks on flanks
Females					
$N = 4$	slate	buff		slate	light brown with slate streaks on flanks
$N = 3$	slate	cream		slate	light brown with fine streaks on flanks
$N = 2$	slate	cream		slate	cream with fine slate streaks

fresher plumage of younger birds, as these edges wear off and are less noticeable after a few months.

All Ayres's Hawk-Eagles, including juveniles, showed the characteristic white patches at the front base of the wings the so-called "landing lights." This characteristic is most obvious when the birds are in flight.

In captivity, the first basic molt of two individuals was almost complete, with just a few juvenile body feathers remaining, and the progression was directly into the adult plumage (as suggested by Brown et al. 1982). However, the head pattern of one eagle changed significantly by the beginning of her sixth year, from a black mask (see Fig. 2 in Hartley 1982 and photograph in Sinclair 1984) to a paler black and white pied or mottled appearance (see photograph in Hartley 1989a). Such a change was not shown by three other eagles over similar time periods. Generally, males had less streaked and blotched chests and flanks than did females. However, the head patterns of males and females overlapped from the completely black-head-mask type (illustrated in Hartley 1989b) to the white forehead-eyebrow and black-eye-mask type so that this distinction could not be used as an aid to identification of the sexes contrary to the suggestion of Brown et al. (1982). The upper wing coverts and back and rump feathers were generally

Table 3. Plumage of adult Ayres's Hawk-Eagles.

EAGLE	CROWN	HEAD		EYE/HEAD MASK	THROAT/CHEST/BELLY
		FOREHEAD/ EYEBROW			
Males					
$N = 1$	black	white/black		black head	white with few black streaks—low density
$N = 1$	black	white/white		black eye	white with black streaks—medium density
$N = 2$	black	white/black		black head	white with fine black srteaks on flanks—medium density
Females					
$N = 2$[a]	black	white/black		black head	white with black streaks and blotches
$N = 5$[b]	black	black/black		black head	white with black streaks and blotches
$N = 3$[c]	black	black/black		black head	heavily blotched black over white

[a] One captive female assumed this plumage by the end of 2 yr, but developed an eye mask by the end of 6 yr.
[b] One individual had a white eyebrow.
[c] Dark morphs.

Figure 2.   Nine-yr old female Ayres's Hawk-Eagle (left) and 5-yr old male (right).

pale edged, and this 'scaled' appearance (see Brown and Davey 1978) can help to distinguish Ayres's Hawk-Eagle from the superficially similar African Hawk-Eagle. Six adult females were dark morphs (Table 3), four of these from Zambia. Two of three adult specimens from South Africa were dark morphs (A. Kemp pers. comm.).

Timing of Molt. Two captive eagles generally started their molt in August–September and had completed it by the end of March. However, one of these had started body molt (not primary, secondary or tail) by 11 May when it was captured as a juvenile (Hartley 1982). To begin body molt well before flight feather molt is usual in African raptors (Edelstam 2001).

Another 11 eagles were recorded molting, each fitting into the period August–March. However, one adult probably started earlier than August, as she had nearly completed her primary molt by the third week of September. By the end of August one eagle had molted three primaries on each wing, while four eagles were proportionately more advanced by mid-September and December respectively. Four other eagles had nearly molted (with

flight feathers nearly finished) by mid-February and another by the end of March.

Eye Color. The eye color of recently-fledged juveniles was light gray. Six months later this had changed to pale yellow. Two juveniles had pale yellow eyes, which changed to bright yellow and yellow-orange, respectively, over the next eight months. In one year, the eye color of one eagle turned deep yellow. We noted no significant difference in eye color between the sexes (but see Brown et al. 1982).

Sightings. P. Mundy recorded 23 sightings (11 adults, six juveniles, and six not aged) of these eagles within Zimbabwe over a 12-yr period (1985–96). All adults were seen singly.

Regular sightings were made in all months of the year in the Zambezi Valley and the eastern highlands (Fig. 1; Table 4). In the Chimanimani area, P. Caldwell-Barr (pers. comm.) recorded adults (in pairs and singly) and juveniles, some attacking birds in aviaries. This suggests that Ayres's Hawk-Eagle breeds in these rugged, heavily-wooded areas in particular. By contrast, in Harare and Bulawayo, they were largely absent from May to De-

Table 4. Summary of sightings and specimens by month of Ayres's Hawk-Eagles in Zimbabwe.

Area	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
Total rural[a]	6	6	9	8	6	5	5	12	17	12	6	15	107
Rukomeche, Kariba, Mavuradonha, Mutare and Chimanimani[b]	x	x	x	x	x	x	x	x	x	x	x	x	
Bulawayo and Harare[a,c,d]	5	9	13	4	2	1	1	4	1			1	41
Bulawayo[c]	x	x	x	x				x	x	x	x	x	

[a] Vernon (1979), Hartley (1982, 1998a), Irwin (1984, 1985), Howells (1985), Tree (1989, 1990, 1991, 1992, 1994, 1995, 1996, 1997), specimens (this study), Hartley (pers. observ.), Mundy (pers. observ.).
[b] Hartley (1982), Tree (1989), K. Hustler, R. Naisbitt, and P. Caldwell-Barr (pers. comm.).
[c] Hartley (1998b).
[d] Irwin (1984), Tree (1989, 1997), Solomon (1995).
[e] Sightings reported (N = 598) in Lendrum (1982).

cember. While they may nest in towns in Zimbabwe, a site has not been found, despite intensive searching for raptor nests by the ZFC and others. It is possible that Ayres's Hawk-Eagles are breeding in heavily-wooded areas relatively close to Bulawayo and Harare, as family groups (i.e., adult male and female, and juvenile) have been seen raiding lofts in these cities.

Nest Location. We report six additional nests (including an alternate site for Bangala, see Phillips 1978) to those reported in Irwin (1981) for Zimbabwe, and one for southern Zambia (Table 5). Data from four nests indicated that the structure consisted of sticks up to 45–60 cm long and 1.8–2.0 cm diameter, but generally they are much thinner and smaller. The nests tend to be small (Table 5), flat on top and deep (Brown and Davey 1978). On average they are smaller than nests of the African Hawk-Eagle which tend to be over 1 m in diameter (Steyn 1982). Nests were located in dense, mature woodland in rugged terrain or in thick, riparian habitats.

In hilly terrain the nests tend to be located on slopes overlooking ravines, four of which can be described as hidden valleys. Several of these nests have been difficult to spot, except at close range, as little as ca. 4 m for nest 4 (Table 5). Nests were placed mainly in a vertical fork or sometimes on a horizontal branch, well inside the canopy. Medium sized, smooth barked trees with heavy foliage were preferred, making nests extra difficult to locate. Nests were in trees that were generally in clumps emergent above the overall canopy of woodland. For instance, nest 1 was well concealed on the lateral branch of a *Syzygium* sp. in a clump of riparian forest on the side of a hill. Nest 4 was in a clump of big *Spirostachys africanus* that covered about 1 ha

(Phillips 1978). Nest 3 was in a tall *Brachystegia glaucescens* growing in a steep gully inside the hills. However, nest 8 was in a *Julbernardia globiflora* connected with the overall canopy in an area of substantial mature woodland on a slope surrounded by relatively flat terrain.

Timing of Laying and Egg Size. In each instance a single egg was laid. A summary of breeding records (ascribed to R. Brooke) was used in Irwin (1981), and this list included four verifiable laying dates in April (reported by C. Vernon) for nest 3 and nest 5 (Phillips 1978), and one laying record for May (Hough 1950). Added to 13 breeding records observed since then, laying occurred in April (N = 10) and May (N = 8).

Mean egg sizes for Zimbabwe were 61.22 mm (SD ± 1.41) × 49.85 mm (±1.51, N = 6). The mass of one egg was 74 g. An egg collected in Zambia was small at 51.3 mm × 42.9 mm (48.5 g). Steyn (1982) also reported small egg size from Zambia (N = 3) and we can offer no explanation for this contrast, especially as there is no apparent difference in the size of eagles between Zimbabwe and Zambia.

Hunting and Prey. Prey items seen on nests by egg collectors have all been birds, often doves (Columbidae), with the exception of one Tree Squirrel (*Paraxerus cepapi*). An adult female was seen eating a Cape Turtle Dove (*Streptopelia capicola*). A released eagle was seen hunting Rock Doves on numerous occasions. She was seen frequently soaring high (ca. 100–200 m) overhead and the Rock Doves were attacked from a vertical stoop. She also took a Green Pigeon (*Treron calva*) chick. She remained in the area for 20 wk and was seen nearly every day. Also, we saw an adult female stoop through the canopy of miombo woodland at

Table 5   Nest site characteristics for Ayres's Hawk-Eagle.

Site (Year)	Tree (Nest Lining)	Habitat	Height Above Ground in m	Nest Diameter in cm (cup)	Nest Depth in cm
1 Nyazura[a] (1950)		riparian (*Syzygium* sp.)			
2 Domboshawa (1959)	*Brachystegia glaucescens*	miombo on domed inselberg			
3 Mtoko (1969, 1970, 1985)	*B. glaucescens* (*Diplorhynchus condylocarpon*)	miombo in ravine—hidden valley in hill range	15	129 (37)	58
4 Mtoko (1972, 1974, 1975, 1980, 1981, 1982, 1993)	*Brachystegia glaucescens* (*D. condylocarpon* and *Tarenna supra-axillaris*)	miombo in ravine—hidden valley in hill range	13	71 (23)	99
5 Bangala[b] (1976, 1977)	*Spirostachys africana* (*S. africana*)	heavily wooded ravine on kopje	9	90 (21)	90
6 Bangala (1990, 1991)	*S. africana*	steep slope on kopje			
7 Mudzi, Mtoko (1987)	*S. africana*	heavily wooded ravine—hidden valley in hill range riparian			
8 Umfurudzi (1976)		hillslope in gorge—riparian			
9 Matusadona (1991)					
10 Choma, Zambia (1981)	*Julbernardia globiflora* (*Brachystegia* sp.)	miombo on slight slope	11	78 (26)	32
11 Eagle Hill[c] Kenya (1950–73)	*Mabaya abyssinica, Ficus* spp. and *Croton megalocarpus*	heavily wooded on hillslope	13	120	60
12 Embu district[d] Kenya (1966–73)	*C. megalocarpus*	heavily wooded			
13 Nairobi[e] (1985, 1986)	*Eucalyptus* sp. (*Eucalyptus* and *Tecomaria capensis*)	plantation in urban gardens	25	60 × 80	45
14 Kibale[f] Uganda (1997)		evergreen forest	32	125	75

[a] Hough 1950.
[b] Phillips 1978.
[c] Brown (1952, 1953).
[d] Brown and Davey (1978).
[e] Dewhurst et al. (1988).
[f] Seavy (2000).

the top of the Chizarira escarpment and nearly snatch a Black-eyed Bulbul (*Pycnonotus barbatus*). All of the eagles captured and shot were frequenting Rock Dove lofts, with the exception of eagles hunting other doves. In captivity, these eagles show a distinct preference for doves, Rock Doves, and small birds, and do not seem to favor mammals such as squirrels (recorded as prey by Brown and Davey 1978).

DISCUSSION

Although marked variations in plumage (Brown 1966, Ash 1981) are supported in this study, some trends noted by Brown (1966) have not been verified. Reduced white forehead and eyebrow and greater extent of buff on the forehead is not necessarily indicative of adult and juvenile males, respectively. Except for a dark-morph, adult female in Mutare (Hartley 1982), none of the adults in this study were as pale or dark as the extremes in Brown and Davey (1978) and the dark morph in Finch-Davies and Kemp (1980). Furthermore, the latter did not display the characteristic landing lights, which is most unusual. Otherwise, the nature of streaking, blotching, wing and tail patterns, and color of the soft parts was in accord with Brown et al. (1982); adult males usually much less streaked on the breast than females (Seavy 2000). It is also possible that observers mistake juvenile Ayres's Hawk-Eagles for Booted Eagles, a rare summer migrant to Zimbabwe.

Timing of molt generally accords with Steyn (1982) and Lendrum (1975) who reported September to February for birds in Bulawayo. This is also outside of the breeding period (egg-laying) and may further confirm that the peak laying period for this species is April–May, with chicks fledged by August–September. Hanmer (1997) examined an adult female captured at Nchalo in February that had probably completed the molt.

Ayres's Hawk-Eagle shows marked reversed sexual dimorphism (Newton 1979), the male being on average 65% of the mass of the female, and about 89% of female size. Brown (1966) emphasized the size difference, but presented few data, including the only record of 714 g for a male (Brown and Davey 1978), and 879 g and 940 g for females. Gape size is small (27.9 mm for female) for a raptor this size, possibly reflecting the preferred diet of small birds (Lendrum 1982, Steyn 1982). Also a specialist aerial hunter of birds, the African Peregrine Falcon (*Falco peregrinus minor*) has a gape of 30 mm (female = 700 g, Hartley 2000).

Ayres's Hawk-Eagle lays a single egg from April–May in Zimbabwe and April–July in Zambia (Steyn 1982). Therefore, several breeding records in Irwin (1981) are questionable, including a two-egg clutch. No authenticated record of a two-egg clutch for Ayres's Hawk-Eagle has been verified by any account and Brown (1966), Brown et al. (1982), Steyn (1982), and Tarboton and Allan (1984) have also questioned such records. Furthermore, a single-egg clutch collected on 25 October is outside the range of laying based on our data. However, an experienced egg collector, B. Neuby-Varty (pers. comm.), collected a single egg on 17 September from a nest located in a large tree in thick bush beside an annual stream in mountainous habitat. This may have constituted a second clutch after a nest failure (Brown 1966). An August record in Irwin (1981) from Hough (1950) was actually for a well grown chick, that was also filmed (J. Hough pers. comm.), and therefore, provides an estimated laying date of May.

In Zimbabwe nests have been found only in well-wooded areas in very rugged terrain (Phillips 1978), usually in close proximity to hills or mountains, but sometimes in riparian forest. In addition, P. Danckwerts (pers. comm.) found two occupied nests along the Kafue River in Zambia. Middleton (2000) studied a raptor community in a 200 km² study area of mainly flat terrain, but that included 29 km² of well wooded, rugged, but smaller kopjes and domed inselbergs south of Phillips' (1978) site. Despite fieldwork over eight years, no nest of Ayres's Hawk-Eagle was found, nor were birds seen. To the south-east in a 40 km² cluster of well wooded, rugged sandstone hills Davison (1998) studied a raptor community over two seasons and found 19 pairs of eagles, but none were Ayres's Hawk-Eagle. Despite the discovery of numerous raptor nests in the Matobo Hills over the past 40 yr by the Black Eagle Survey team, Ayres's Hawk-Eagle is regarded as a vagrant (Gargett 1990). The same applies to four other intensively-surveyed areas in well-wooded, domed inselberg terrain (R. Hartley unpubl. data). As Ayres's Hawk-Eagle soars a great deal (Clark 1999) and displays conspicuously during courtship (Brown 1966), it is unlikely that they would be overlooked during these surveys.

Generally Ayres's Hawk-Eagles have been absent from Zimbabwe towns during May–July (Table 4), while a similar pattern was noted in the Transvaal

(Tarboton and Allan 1984) and southern Botswana (Herremans 1994), where the species was absent for the winter months south of Zimbabwe (Harrison et al. 1997). A pair of Ayres's Hawk- Eagles bred in a stand of gum trees (*Eucalyptus* sp.) in Nairobi and another two pairs were also observed (Dewhurst et al. 1988). With the exception of these, plus three observations reported in this paper, all previous records in towns have been for solitary birds (Hartley 1982, Lendrum 1982, Tarboton and Allan 1984), which were probably nomads (Hartley 1998b), rather than migrants.

A great danger to these birds is, in fact, their attraction to towns where they come into frequent contact with domestic and racing Rock Doves and ultimately with the owners (Lockwood 1979, Hartley 1982, Lendrum 1982, Tarboton and Allan 1984, Herremans and Brewster 1994, Hartley et al. 1996). Some domestic pigeons are worth large sums of money. The ZFC and the Department of National Parks and Wild Life Management (DNPWLM) have established contact with the Zimbabwe Racing Pigeon Association (ZRPA) and it is vital that this be maintained. Although two of these eagles were accused of harassing poultry, these events may have been cases of mistaken intention as Ayres's Hawk-Eagle does not usually molest poultry (Hartley 1982, Lendrum 1982, Dewhurst et al. 1988). Hartley et al. (1996) reported habitat destruction as another negative impact and recommended that Ayres's Hawk-Eagle be closely monitored.

In Zimbabwe, South Africa, and Kenya, 15 females and three males were recovered in towns. The greater frequency of females is possibly a response to the size of domestic and racing Rock Doves (300–350 g), which are easily tackled and carried by the heavier females, rather than by smaller males.

That the Ayres's Hawk-Eagle lays only one egg and can produce no more than one youngster reflects some limitation to available prey. (Newton 1979). This is supported by the apparent patchiness of its nesting density, despite Brown's (1966) suggestion that its home range is ca. 25 km². The similar Booted Eagle occurs at much higher densities in the Cape Province of South Africa (Steyn 1982) and it produces up to two eggs (and both chicks can survive). The Booted Eagle also hunts from a stoop, but it is a generalist with birds contributing about 50% of its prey. Small mammals, reptiles (mainly lizards) and insects are also taken

which may allow it to capture more prey than does the Ayres's Hawk-Eagle, and consequently it is more abundant. Another generalist, the African Hawk-Eagle, also occurs much more frequently than Ayres's Hawk-Eagles and sometimes is relatively abundant in hills during the nesting period.

Predation (Dewhurst et al. 1988) and poor breeding success (Brown 1974) have been suggested as reasons for the rarity of Ayres's Hawk-Eagle. Predation can occur frequently on raptors, including on some large eagles (Davison 1998). We suggest that predation may explain the tendency to select relatively concealed positions for nesting. Ayres's Hawk-Eagle is the smallest winter-breeding eagle, and although it sometimes shares its hill site nesting habitat with African Hawk-Eagle and other eagles, Brown (1966) recorded little antagonism between them at his Eagle Hill study site. Aggressive Peregrine (Brown 1966) and Lanner falcons (*F. biarmicus*) (Phillips 1978), on the other hand, have probably interfered with breeding success of the Ayres's Hawk-Eagle. It is also possible that this eagle owes its rarity to its role as a specialist bird predator, using its equally specialized method of attacking from a stoop. Clark (1999) contended that it is overlooked, because observers are not searching the sky. While it is clear that the Ayres's Hawk-Eagle is not as scarce as some authorities claim (Brown et al. 1982, Steyn 1982, Maclean 1993, Clark 1999), it is still a rare species.

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BREEDING DENSITY AND ALTITUDINAL DISTRIBUTION OF THE URAL, TAWNY, AND BOREAL OWLS IN NORTH DINARIC ALPS (CENTRAL SLOVENIA)

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ABSTRACT.—Ural (*Strix uralensis*), Tawny (*Strix aluco*), and Boreal owl (*Aegolius funereus*) density and altitudinal distribution were determined using playback to census owls on Mt. Krim (North Dinaric Alps, central Slovenia). Survey points were selected proportionally by altitude according to the relief of the area (320–1060 masl). Density of Ural Owls was estimated to be 2.2 territories/10 km^2; high relative to published data from Europe, while densities of Tawny (4.0 territories/10 km^2) and Boreal owls (2.8 territories/10 km^2) were in the range or lower than other European data. The Tawny Owls were found at significantly lower altitudes (320–850 masl), while Boreal Owls were at higher altitudes (700–940 masl) than expected. I suggest that Ural Owl territories were located in suboptimal habitat for Tawny Owls. The segregation of these owls by altitude in temperate-zone, continuous-montane forests is either a consequence of competitive exclusion or predation. The similarity in altitudinal distribution between Tawny and Boreal owls was low, suggesting that Tawny Owl territories are not suitable habitat for Boreal Owls. At high altitudes, harsh conditions prevent the Tawny Owl from competing with the Ural Owl; an advantage for the Boreal Owl, which was capable of surviving harsh conditions within Ural Owl territories. Further studies are needed to determine competitive exclusion or predation interactions among these owls.

KEY WORDS: *Boreal Owl;* Aegolius funereus; *Tawny Owl;* Strix aluco; *Ural Owl;* Strix uralensis; *altitudinal distribution; density; Dinaric Alps; Slovenia.*

DENSIDAD DE ANIDAMIENTO Y DISTRIBUCIÓN ALTITUDINAL DE LOS BUHOS URAL, LEONADO Y BOREAL EN LOS ALPES DINARICOS DEL NORTE (ESLOVENIA CENTRAL)

RESUMEN.—La densidad y distribución altitudinal de los búhos ural (*Strix uralensis*), leonado (*Strix aluco*), y boreal (*Aegolius funereus* o búho de Tengmalm) se determinó usando play back para censar búhos en Mt. Krim (alpes dinaricos del norte, Eslovenia central). Los puntos de conteo fueron seleccionados proporcionalmente de acuerdo con el relieve del área (320–1060 msnm). La densidad de los búhos urales se estimo en 2.2 territorios/10 km^2; relativamente alta con respecto a datos publicados en Europa, mientras que la densidad de búhos leonados (4.0 territorios/10 km^2) y búhos boreales (2.8 territorios/ 10 km^2) estuvieron en el rango o por debajo de otros datos tomados en Europa. Los búhos leonados se encontraron en alturas significativamente mas bajas (320–850 msnm), mientras que los búhos boreales se encontraron altitudinalmente mas arriba (700–940 msnm) de lo esperado. Sugiero que los territorios del búho ural estaban localizados en hábitat suboptimo para búhos leonados. La segregación de estos búhos por altitud en un bosque montano continuo de zona templada es tanto una consecuencia de exclusión competitiva como de depredación. La similitud en la distribución altitudinal entre búhos leonados y boreales fue baja, sugiriendo que los territorios de búho leonado no proveen de hábitat adecuado a los búhos boreales. En elevadas altitudes, las duras condiciones impiden al búho leonado competir con el búho ural; una ventaja para el búho boreal, el cual fue capaz de sobrevivir a difíciles condiciones dentro de los territorios del búho ural. Se requiere de mayores estudios para determinar la exclusión competitiva o las interacciones de depredación entre estos búhos.

[Traducción de César Márquez]

Bird densities and their altitudinal distributions are influenced by habitat quality, competitive behavioral mechanisms, food supply, and availability of suitable nest sites (Gill 1995, Zabel et al. 1995, Newton 1998). For owls, defense of an exclusive hunting territory plays an important role; the size of the territory is

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often governed by owl mass and prey scarcity (Schoener 1968, Carbone and Gittleman 2002).

In the Dinaric Alps (western Balkan Peninsula) the ecology of Ural (*Strix uralensis*), Tawny (*Strix aluco*), and Boreal owls (*Aegolius funereus*) is poorly known. Density and some breeding habits of Ural Owls are documented for Slovenia (Mihelič et al. 2000), but only anecdotal data are available from other parts of the region (Kralj 1997). For the Tawny and Boreal owls, only distribution is known. Prior to this paper, the altitudinal distribution of owls from Dinaric Alps were based on several incidental observations (Tome 1996, Mihelič et al. 2000).

In this paper, I present data on density and altitudinal distribution of the Ural, Tawny, and Boreal owls from the north part of Dinaric Alps. Of particular value are data on the Ural and Boreal owls, because the study area is at the southern limit of their distribution and is disjunct from the main European population; both species are glacial relics.

STUDY AREA

The field work was done on Mt. Krim (14°25'55"E, 45°58'15"N) in a study area covering 140 km², 10 km south of Ljubljana (central Slovenia), between 1997 and 2000. Mt. Krim is a medium-high mountain (290–1107 masl) with a widely extended plateau. Most of the study area is north facing and is within the Dinaric zoogeographical region (Mršić 1997), part of the north Dinaric Alps.

Clearings or nonforest areas, both natural and man-made, represent 25% of the study area. They are small and dispersed, mostly around the settlements. The mixed forest is widespread (75%), belonging to the association of Dinaric beech forest with fir (*Omphalodo-Fagetum* s. lat.) appearing in different subassociations. The most frequent subassociation is *Omphalodo-Fagetum asaretosum europaei* (syn. *Abieti-Fagetum dinaricum clematidetosum*; for descriptions see Puncer 1980). Dominant tree species are silver fir (*Abies alba*), Norway spruce (*Picea abies*), and beech (*Fagus sylvatica*). Most of the trees in the forest have trunk diameter >30 cm. (Furlan 1988, Slovenian Forest Service unpubl.)

METHODS

To estimate owl density and altitudinal distribution, 41 survey points were selected from the base to the top of Mt. Krim. Survey points were selected proportionally by altitude. Density was estimated in the breeding season 1998 only, but the data for altitudinal distribution were collected between 1997 and 2000. Survey points were located about 1000 m apart, a distance recommended by Holmberg (1979) and Zuberogoitia and Campos (1998). The detection of owls was enhanced by using call playback (Forsman 1983, Redpath 1994, Zuberogoitia and Campos 1998, Appleby et al. 1999). Recordings of male territorial calls of Ural, Tawny, and Boreal owls were used

(Roché and Mebs 1989). Surveys were conducted from dusk to approximately midnight during the spring and summer, up to three times per month. Playbacks were broadcast for 10 min, followed by a 5-min listening period, at each survey point; a sampling interval suggested to be adequate for detecting most owls that are occupying a territory (Zuberogoitia and Campos 1998). On a specific survey night, only one species' call was used during broadcast sampling.

I estimated human detection of the playback in forest habitat with the equipment used in the survey at a distance of ca. 500 m. This distance was used to define the effective survey area (0.78 km²) around each survey point. I assumed that each response at a point represented an occupied territory. The presence of two owl territories at one point count was recorded only if two males were detected at the same time. Spontaneous calling owls, that were estimated to be outside (>500 m from point) the survey area, were excluded from further analysis.

Crude density was estimated as the sum of all survey areas at all altitudes divided by the number of detected owl territories. Because territory-size data were not obtained, only approximations of ecological density were possible. Ecological densities (the number per unit of habitat space; Odum 1971) were calculated from survey areas within the lowest and the highest recorded altitude for species; only forest-covered areas were used in the analysis. Similar approaches to approximate owl densities were employed by Penteriani and Pinchera (1990) and Diller and Thome (1999).

The owl altitudinal distribution was presented as a relative abundance index. This standardized relative abundance was calculated as number of owl territories per survey point in a 100 m altitudinal interval per year. I defined altitudinal range with 50% of all detected owl territories as the center of altitudinal distribution for each species. Disproportionate use of a particular altitude by each owl species was tested with Mann-Whitney U-test (Sokal and Rohlf 1995) comparing the altitudinal distribution of all survey areas with the altitudinal distribution of survey areas with occupied owl territories. A similarity index of altitudinal distribution between three owl species was calculated using the MacNaughton-Wolf similarity index as suggested by Mikkola (1983) and Korpimäki (1986).

RESULTS

In 1998, 343 survey points were completed in 25 nights. Seven Ural Owl, 13 Tawny Owl, and nine Boreal Owl territories were found on 41 survey areas. Crude densities of Ural, Tawny, and Boreal owls were estimated at 2.2, 4.0, and 2.8 territories/ 10 km² respectively. Estimated ecological density was measurably higher only in the Boreal Owl (Table 1).

In years 1997–2000, 582 survey points were done during 50 nights. Twenty occupied territories of Ural, 23 of Tawny, and 17 of Boreal owls were recorded. The Ural Owl occurred over the greatest

Table 1. Estimated crude and ecological densities of three owl species in 1998 on Mt. Krim. Crude density is the sum of all survey areas divided by the number of detected owl territories (see Methods). Ecological density is the number of owl territories per unit of habitat space (calculated on the basis of sample area).

	Ural Owl	Tawny Owl	Boreal Owl
Crude density (territory/10 km^2)	2.2	4.0	2.8
Ecological density (territory/10 km^2)	2.8	5.6	6.9
Sample area (km^2)	25.1	23.0	13.0

span in altitudinal distribution (410–1060 masl; Fig. 1). The Tawny Owl was found at significant lower elevations, while Boreal Owls occurred at higher altitudes (Table 2, Fig. 1). The greatest sim-

ilarity regarding altitudinal distribution was found between Ural and Boreal owls, and the least similarity was found between the distribution of the Tawny and Boreal owls (Table 3).

DISCUSSION

Ural Owl Density. Density of Ural Owls in North Dinaric Alps (including Mt. Krim) is high relative to other parts of Europe (Table 4). I suggest three possible explanations for these differences. First, different census methods may be responsible; we counted singing males, while active nests were counted in some other studies. With the playback technique, it is impossible to distinguish between breeding and nonbreeding pairs or even nonmated, but territorial individuals. Pairs can occupy a territory even if they do not breed (Saurola 1989). The proportion of Ural Owl pairs that actually lay eggs varies between 12 and 87% (Pietiäinen 1988).
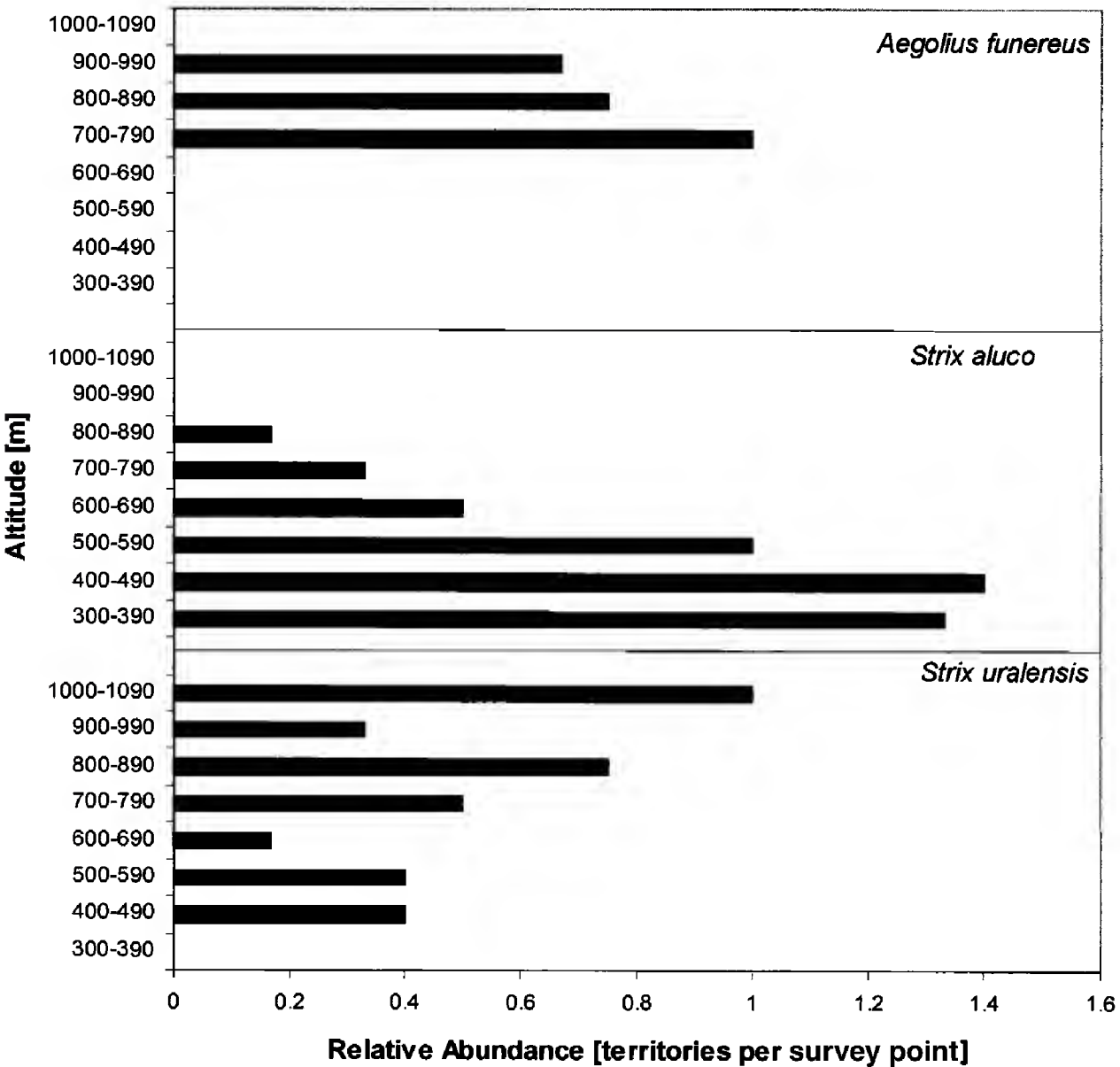
Figure 1. Altitudinal distribution of Ural ($N = 20$), Tawny ($N = 23$), and Boreal owl ($N = 17$) on Mt. Krim. Relative abundance was calculated as the number of owl territories per survey point in each 100 m altitudinal interval per year.

Table 2.   Altitudinal distribution of all survey areas compared to survey areas, where Ural Owls, Tawny Owls, and Boreal Owls were detected in years 1997–2000 on Mt. Krim. Data were compared with Mann-Whitney U-test.

	MEDIAN	ALTITUDE (m) MINIMUM– MAXIMUM	CENTER OF ALTITUDINAL DISTRIBUTION[a]	U	P
All survey areas (N = 4)	710	320–1060	520–820		
Survey areas with Ural Owls (N = 20)	800	410–1060	650–840	271.0	>0.05
Survey areas with Tawny Owls (N = 23)	490	320–850	410–610	223.5	0.033
Survey areas with Boreal Owls (N = 17)	800	700–940	770–850	163.5	0.037

[a] Center of altitudinal distribution contains 50% of all detected owl territories.

For that reason density is herein presented as occupied territories and not as breeding pairs. Secondly, density in birds is a function of the size of the study area (Bezzel 1982). Areas with low densities of owls were considerably larger than my study area (Table 4). Finally, the amount of available food may be responsible. In Slovenia, a large part of Ural Owl's diet consists of fat dormouse (*Glis glis*) (Vrezec 2000b), while in other countries, voles (*Microtus* spp.) are the predominant prey species (Sladek 1961/62, Mikkola 1972, 1983, Jäderholm 1987, Korpimäki and Sulkava 1987, Glutz von Blotzheim and Bauer 1994, Czuchnowski 1997, Stürzer 1998, 1999). Fat dormouse is an abundant small mammal in Slovenian forests (Kryštufek 1991) and its mass is approximately four times as much as voles, that is 245 g compared to 64 g (Kryštufek 1991, Glutz von Blotzheim and Bauer 1994). Prey availability and prey body mass are important factors that inversely affect the size of a predator's territory (Schoener 1968, Zabel et al. 1995). One consequence of large territories is a relatively lower density of owls (LaHaye et al. 1997). Prey availability on Mt. Krim could result in small territories and may explain the observed

Table 3.   Similarity in altitudinal distribution between three owl species on Mt. Krim (MacNaughton-Wolf similarity index following Mikkola [1983] and Korpimäki [1986]).

	URAL OWL	TAWNY OWL
Boreal Owl	0.65	0.17
Tawny Owl	0.42	

high density of the Ural Owl. However, I have no data on fat dormouse density on Mt. Krim to support this suggestion.

Tawny Owl Density. According to data from Europe (Table 4), density of Tawny Owls on Mt. Krim was low; perhaps, because of interspecific competition with the larger Ural Owls (Mikkola 1983, König et al. 1999, Vrezec 2000a). The Tawny Owl is lowland species in Slovenia (Tome 1996), and that was confirmed also on Mt. Krim (Fig. 1).

Boreal Owl Density. The Boreal Owl has a relatively small territory (König et al. 1999). Neighboring males can sometimes sing very close to each other without any aggressive interactions (König et al. 1999), so ecological densities can exceed 10 pairs/10 km² (Table 4). Three important factors that limit Boreal Owl density in forests were advanced by Locker and Flügge (1998): (1) presence of suitable nest tree holes of Black Woodpeckers (*Dryocopus martius*); (2) optimal foraging areas, large clearings or windfall areas; and (3) absence of the Tawny Owl, an important predator of Boreal Owls throughout Europe. In the area of Mt. Krim all factors are optimal, so high ecological densities are no surprise. Low crude density (Table 2) is the consequence of altitudinal limitations of the species' distribution, which was probably caused by the presence of Tawny Owls at lower altitudes.

Altitudinal Partitioning. The present study has shown that in North Dinaric Alps, competing owl species are segregated by altitude, an important factor in habitat selection for some species such as for Tawny and Boreal owls. The Ural Owl is the dominant species in the owl guild living in my study area, and its distribution is not restricted by

Table 4. Size of study areas and densities (pairs or territories/10km²) of Ural, Tawny, and Boreal owls in Slovenia and Europe.

	Ural Owl		Tawny Owl		Boreal Owl		Sources
	Density[a]	Area (km²)	Density[a]	Area (km²)	Density[a]	Area (km²)	
This study	2.2	32.2	4.0	32.2	2.8	32.2	Benussi and Genero 1995, Vogrin 1998, Mihelič et al. 2000
Slovenia	2.0–5.0	13.0–15.7	0.7	210.0	—	—	
Germany	0.5–1.0	10.0	0.2–16.0	10.0–137.0	0.5–16.0	28.0–200.0	Glutz von Blotzheim and Bauer 1994, März 1995, Locker and Flügge 1998, Stürzer 1999, Mebs and Scherzinger 2000
Italy	—	—	4.0–11.0	16.0–122.0	—	—	Penteriani and Pinchera 1990, Galeotti 1994
Austria	—	—	9.0–25.0	25.0	—	—	Dvorak et al. 1993
Switzerland	—	—	4.8	21.0	1.2–4.5	15.0–150.0	Penteriani and Pinchera 1990, Augst 2000, Mebs and Scherzinger 2000
Spain	—	—	0.8–7.1	2384.0–11 317.0	—	—	Zuberogoitia and Campos 1998, Sanchez-Zapata and Calvo 1999
Great Britain	—	—	22.0	10.2	—	—	Hirons 1985
Denmark	—	—	4.0–20.0	53.2–65.0	—	—	Penteriani and Pinchera 1990, Grell 1998
Poland	3.0	60.0	0.8–6.0	250.0–485.0	—	—	Penteriani and Pinchera 1990, Czuchnowski 1997, Mebs and Scherzinger 2000
Finland	0.1–1.0	4800.0	2.0	104.3	1.0	104.3	Glutz von Blotzheim and Bauer 1994, Solonen 1996, Pietiäinen and Saurola 1997
Sweden	0.2–3.0	10.0–100.0	—	—	—	—	Hirons 1985, Glutz von Blotzheim and Bauer 1994
Estonia	0.2–0.3	10.0	—	—	—	—	Mikkola 1983
Belorus	0.4–0.9	140.0–760.0	—	—	—	—	Tischechkin and Ivanovsky 2000
Russia	24	25.0	—	—	—	—	Mikkola 1983

[a] Pairs or territories/10 km².

altitude (Mihelič et al. 2000). Studies from Scandinavia indicate keen interspecific competition between both *Strix* owls (Lundberg 1980, Korpimäki 1986). However, work from the more temperate climates of Central Europe, where the Ural Owl was reintroduced, did not report competition between Ural and Tawny owls (Stürzer 1998). It is possible, that in mild weather conditions, especially in lowlands, the Tawny Owl can coexist with the Ural Owl, while in more extreme conditions (northern limit of distribution or high altitudes), the Ural Owl out-competes the smaller Tawny Owl. Low breeding density of Tawny Owls at Mt. Krim, compared to other European countries (Table 4), could indicate, that the Ural Owl is a limiting factor. Evidence of regular breeding of the Tawny Owl at elevations over 1000 masl, where it is allopatric with Ural Owls, is needed.

The altitudes occupied by the Tawny Owl are unsuitable for Boreal Owls. At high altitudes, harsh conditions prevent the Tawny Owl from competing with the Ural Owl; an advantage for the Boreal Owl, which was capable of surviving harsh conditions within Ural Owl territories. Boreal Owls are able to breed in Ural Owl territories, although their density and breeding activity can be reduced (Hakkarainen and Korpimäki 1996). On the contrary, as shown with altitudinal segregation in this and some other studies from Central and Southern Europe (Pedrini 1982, Glutz von Blotzheim and Bauer 1994, Locker and Flügge 1998, Augst 2000), Tawny Owls seem to exclude Boreal Owls from their territories. Further studies are needed to examine the competitive and predation interactions among these two owls.

Few studies have dealt with the altitudinal distribution of owls. The present study showed that owl density or abundance can vary substantially according to altitude in some species (Fig. 1). Owl survey studies in areas with elevations ranging more than 500 m should record altitude. For accurate estimations of owl densities or abundance, all altitudes with suitable habitat should be surveyed. Normally, such surveys cover very large areas, which are impossible to search intensively. A sampling approach stratified by altitude should be used. Although the accuracy of density estimates based on broadcast sampling permit comparisons with other studies (Table 4), the reliability of this method should be tested more thoroughly to determine the relationship of resulting estimates to absolute population size.

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SHORT COMMUNICATIONS

FALL MIGRATION OF THE WHITE-TAILED HAWK IN CENTRAL BOLIVIA

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KEY WORDS: *White-tailed hawk*; Buteo albicaudatus; *migration*; *flocks*; *thermals*.

Relatively little is known about raptor migration in Bolivia (Davis 1989, 1994, Zalles and Bildstein 2000, Olivo 2001). The White-tailed Hawk (*Buteo albicaudatus*), is a partial migrant in South America, whose North American populations also are thought to be migratory (Bildstein and Zalles 1998, Zalles and Bildstein 2000). The species distribution is mainly tropical, ranging from southwestern United States to Argentina (Sick 1993). There is only one report of migration for the species in South America (in Brazil through Ilha do Cardoso in January, Zalles and Bildstein 2000). In Bolivia, records indicating the distribution of White-tailed Hawks have been documented (Arribas et al. 1995), but no information on migration of this species has been reported.

Observations were carried out at the airstrip at Viru-Viru International Airport, 15 km north of the city of Santa Cruz (17°36′30″S, 63°09′25″W) in Central Bolivia. Surveys were made on 17–22 and 24 November 2000 by two observers, from 0900 to 1700 H, for a total of 51 hr. Observations were made using 8 × 30 binoculars and a scope of 60×.

A total of 477 White-tailed Hawks were counted. All birds exhibited unidirectional soaring or southward flapping flight.

None of the hawks were observed to stopover. A solitary juvenile stopped near a lagoon to rest for a few minutes, and several solitary adults perched on communication towers very close to the observers. When these birds perched, we observed the rusty shoulders, that the wing tips projected beyond the end of the tail, and some fine bands in the tail in addition to the primary black band; all of which are field marks for this species.

The frequency of migrating hawks for a single week was 8.5 hawks/hr. Two flocks were recorded, one of 203 hawks on 17 November and the second with 206 hawks on 20 November 2000. A few individuals flew alone (14%, *N* = 477).

We confirmed the identification of all single migrating hawks. The two large flocks flew over rapidly, however, and we were able to verify the identification of ca. 80 individuals in both flocks (or 17%, *N* = 477). One solitary migrant was classified as a juvenile, the rest were recorded as adults.

There was a noticeable hourly pattern, 91% (433 hawks) were observed between 1100 and 1300 H, when thermals were well developed. Most of the hawks seemed to use thermals to aid their migration; only the second flock observed had a tail-wind in front of an approaching storm.

Hudson (1920) and Wetmore (1943) have reported migratory movements by White-tailed Hawks, but details are convincing. These citations may refer to passages of Swainson's Hawks, because White-tailed Hawks may join flocks of Swainson's Hawks briefly, then drop out and return to a local activity area (K. Bildstein pers. comm). According to Fuller et al. (1998), migrating Swainson's Hawks funnel through this region of Bolivia during southward migration over South America. Zalles and Bildstein (2000), however, only report migrating Swainson's Hawks in large numbers near the village of Masicuri in Bolivia.

The southward movements of White-tailed Hawks we documented may correspond to a tropical breeding population residing north of our sampling location, rather than a more southern austral breeding population. However, further studies are needed to clarify migration on this little-known species.

Previously, Davis et al. (1995) and Zalles and Bildstein (2000) did not report any White-tailed Hawks migrating through Viru-Viru. These workers did note the migration of Snail Kites (*Rostrhamus sociabilis*) numbering 30 000 individuals in this area in November.

Regretfully, there are no previous reports of migratory movements of the White-tailed Hawk in South America. Hence, more studies are needed to determine the importance of Viru-Viru as part of a migratory route of White-tailed Hawks. Such research should determine the dates of early, peak, and late movements as well as identify the origins and destinations of these migrating hawks.

RESUMEN.—El busardo de cola blanca (*Buteo albicaudatus*), es un migrador parcial en América del Sur. No ex-

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isten observaciones de movimientos migratorios de la especie en Bolivia. Entre el 17 y el 24 de noviembre del 2000, se contaron un total de 477 individuos, volando solos o en bandadas en el Aeropuerto Internacional de Viru-Viru, en Bolivia. Todas las aves exhibieron un vuelo de planeo o aleteo unidireccional hacia el sur. La tasa de paso fue de 8.5 halcones por hora. La mayoría de las rapaces 91% fueron registrados entre las 11 de la mañana y la 1 de la tarde.

[Traducción del autor]

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NOCTURNAL ARRIVAL AT A ROOST BY MIGRATING LEVANT SPARROWHAWKS

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Most soaring birds (i.e., raptors, *Accipiteridae*, pelicans, *Pelicanus* spp., storks, *Ciconia* spp., and cranes, *Grus* spp.) require rising air currents, thermals, over and slope-updrafts to accomplish their long distance movements (e.g., Porter and Willis 1968, Safriel 1968). On migration, or other long-distance movements, this requirement restricts species with a heavy wing loading to regions (i.e., land masses vs. bodies of water) where thermals and updrafts occur and dictates diurnal flight (Spaar 1997). This soaring strategy is used almost exclusively by the large raptor species (eagles, buteos) because they are mostly incapable of generating sufficient power for sustained flapping flight (Pennycuick 1972). Smaller raptors (harriers, *Circus* spp., falcons, *Falco* spp., sparrowhawks, *Accipiter* spp.) however, can resort to flapping (powered)-gliding flight (Spaar 1997) during inclement weather conditions, or at night (Stark and Liechti 1993, Spaar and Stark 1996).

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Table 1. Number of Levant Sparrowhawks observed arriving after dark at palm plantations at Eilat, Israel. Time is presented as minutes after sunset (0). Data are presented Mean ± SD for the seven nights observations were undertaken.

Min After Sunset	Mean	SD	Total	Percent
0–30	20	9	136	<1
30–60	309	28	2164	10
60–90	612	174	4286	19
90–120	1049	151	7341	33
120–150	1158	99	8104	37
150–180	13	7	90	<1
>180	0			
Total			22 121	

Israel, the only land bridge between three continents, is at a junction for birds migrating south from Eurasia to Africa in autumn and north to their breeding grounds in spring (Safriel 1968). In spring the Red Sea and the Gulf of Aqaba/Eilat act as a long deflection barrier diverting many northbound raptors to Eilat (Shirihai and Christie 1992, Yosef 1995, Grieve 1996). Eilat is at the northern edge of almost 2000 km of continuous desert regions of the Sinai and the Sahara. Hence many birds land here to rest after crossing deserts to the south (Safriel 1968, Yosef 1998a).

Recent studies document that during the northbound migration Levant Sparrowhawks (*Accipiter brevipes*) concentrate in the Eilat region in great numbers (e.g., 45 000–50 000; Safriel 1968, Shirihai 1987, Yosef 1995, Clark and Yosef 1997, Shirihai et al. 2000, Yosef and Fornasari 2000) and migrate north along the Great Rift Valley towards Syria and Lebanon (Frumkin et al. 1995). Levant Sparrowhawks are considered scarce, and Cramp and Simmons (1980) state that information on their distribution, populations, and status is limited. Recoveries of birds banded at Eilat during northbound migrations are from Romania, Ukraine, Russia, and Syria (Yosef 1998b).

During the trapping and banding operations of spring 1996, 1997, and 1998, we noted that although we remained in the vicinity of the palm (*Phoenix dactylifera*) plantations until dark we seldom saw Levant Sparrowhawks arrive, and yet on the next morning we observed large numbers departing from the palmeries on their migration north along the Syrio-African Rift Valley. Stark and Liechti (1993) suggested that Levant Sparrowhawks might resort to flapping flight to reduce time spent on migration (i.e., that they were time minimizers—that minimize overall migration time from Africa to their Asian and European breeding sites). Using radar, they identified the "signature" wing-beat pattern of Levant Sparrowhawks at night in autumn 1991. This led to a prediction that based on

Table 2. Number of Levant Sparrowhawks observed arriving after dark at palm plantations at Eilat, Israel, and the numbers counted lifting off the next morning. Number in parentheses represents the percentage of birds counted arriving at roost in the dark, or trapped the next morning, in comparison to those counted at lift off from the same area the following morning.

Date	N Detected at Roost (Percent)	N Counted at Lift Off		N Trapped (Percent)
18 April	1136 (31)	19 April	3111	22 (0.7)
19 April	1201 (24)	20 April	4432	36 (0.8)
20 April	3752 (53)	21 April	7018	31 (0.4)
21 April	6726 (70)	22 April	9652	36 (0.4)
22 April	6040 (71)	23 April	8422	44 (0.5)
23 April	90 (16)	24 April	546	19 (3.5)
24 April	3176 (59)	25 April	5344	53 (1.0)
TOTAL	22 121 (57)	7	38 525	241 (0.6)

the number of birds I observed at the palm groves after sunset, I could predict the volume of the flocks that would take off early the next morning, and thereby increase our trapping success the next morning.

METHODS AND MATERIALS

I conducted seven night watches during the peak migration period of the Levant Sparrowhawk (18 April–24 April) in the spring 1998 season. Observations were initiated at sunset and continued until no flocks or individual birds were seen for at least 30 min. I used a Swarovski NC2 night scope (×4 magnification) to time the arrival of the flocks and to estimate their numbers. For convenience of calculation I split the observation period into 30 min blocks I opted to observe the northern of the two palm plantations owing to logistic constraints along the Israeli–Jordan border Data were recorded on appropriate observation sheets and are presented as mean values ±SD (Table 1).

RESULTS AND DISCUSSION

I observed after-dark arrival by Levant Sparrowhawk on all seven nights of observation. For the first 60 min after sunset very few arrivals were noted. An increase in the number of arrivals was noted between 90–150 min post-sunset (Table 1). No Levant Sparrowhawks were observed arriving after 180 min post-sunset. Numbers estimated with the night scope were consistently lower than the numbers observed at lift-off at dawn the next morning (Table 2). I attribute this to two major factors—my visibility being restricted to the magnification available in the night scope, and that the limited field of vision at night prevented the discovery of flocks that arrived along the shoreline of the Red Sea from the south to the southern palmeries and remained undetected until the next morning. However, the early warning of the numbers ar-

riving at the roost allowed the trapping team to organize the trapping equipment appropriately and during the study period a record total 368 Levant Sparrowhawk was trapped (Table 2). This is in contrast to the trapping success during the two years (1996, 1997) prior to the night observations and four subsequent years (1999–2002) when no such observations were conducted and the numbers of Levant Sparrowhawks trapped was less than 200 individuals per season.

Data suggest that south of Israel a larger than previously reported proportion of the Levant Sparrowhawk population resorts to nocturnal flight in order to minimize the time spent over inhospitable areas. Spaar et al. (1998) showed that migratory strategy depend on feeding conditions en route and that in good conditions a nonstop flight strategy of soaring-gliding during daylight hours and flapping-gliding flight during the night is the time minimizing strategy. However, under poor conditions, soaring-gliding flight when thermal convection is available and roosting during the night is the energy- and time-minimizing strategy. The fact that 22 121 Levant Sparrowhawks, i.e., 57% of total observed, were observed arriving at a single roost site up to two hours after sunset suggests that the latter appears to be the case for the Levant Sparrowhawk at Eilat. Stark and Leichti (1993) argued that nocturnal migrants minimized time to join larger flocks for the next day's migration. Spaar et al. (1998) thought that the very short period of their passage in Israel suggests that the migratory timing of the Levant Sparrowhawks was under strong endogenous control and that delays in the migratory timing was compensated by nocturnal flights, as has been shown for Tree Pipits (*Anthus trivialis*, Jenni 1984). In contrast, Kerlinger (1989, 1995) thought that raptors that undertake long crossings of barriers, and are unable to complete them during daylight, would resort to nocturnal migration. However, the above does not entirely explain why a substantial proportion of the population arrives at Eilat several hours after dark and do not stop at other human settlements, to the south of Eilat, in the Sinai Peninsula or along the Red Sea coast. Hence, I assume that these species have knowledge, based on previous migrations or innate, of specific staging areas along the migratory route at which they roost and will resort to nocturnal migration to reach them.

The data presented here, which validate previous radar studies based on "flight signature" (e.g., Casement 1996, Stark and Leichti 1993), represent the first time that migratory raptors have been observed and identified at close range with a nightscope arriving at a roost site.

During banding operations we noted that although we remained in the vicinity of the palm plantations until dark we seldom saw Levant Sparrowhawks (*Accipiter brevipes*) arrive, and yet on the next morning we observed large numbers departing from the palmeries on their migration north along the Syrio-African Rift Valley. We predicted that based on the number of birds observed at the palm groves after sunset, I could estimate the volume of the flocks that would take off early the next morning,

and thereby increase our trapping success the next morning. I conducted seven night watches during the peak migration period of the Levant Sparrowhawk in spring 1998. Observations were initiated at sunset and continued until no flocks or individual birds were seen for at least 30 minutes. I used a Swarovski NC2 night scope (×4 magnification) to time the arrival of the flocks and to estimate their numbers. For the first 60 minutes after sunset very few arrivals were noted. An increase in the number of arrivals was noted between 90–150 min post-sunset. No Levant Sparrowhawks were observed arriving after 180 min post-sunset. The early warning of the numbers arriving at the roost allowed the trapping team to organize the trapping equipment appropriately and during the study period a record total 368 Levant Sparrowhawk was trapped. The data represent the first time that migratory raptors have been observed and identified at close range with a nightscope arriving at a roost site.

RESUMEN.—Durante las operaciones de marcaje notamos que aunque permaneciéramos en la vecindad de las plantaciones de palma hasta oscurecer, contadas veces vimos arribar azores del mediterráneo oriental (*Accipiter brevipes*), y con todo, a la mañana siguiente vimos grandes números partiendo de las palmeras en su migración hacia el norte a lo largo del valle de la falla Sirio-Africana. Predecimos que con base en el numero de aves observadas en el boscaje de palmas después del ocaso, podríamos estimar el volumen de las bandadas que despegarían temprano en la mañana siguiente, y por tanto incrementar nuestro éxito de capturas en la mañana siguiente. Lleve a cabo siete rondas nocturnas durante el periodo pico de la migración del azor del mediterráneo oriental en la primavera de 1998. Las observaciones se iniciaban al caer el sol y continuaban hasta que ninguna bandada o individuo fuera visto por al menos en 30 minutos. Usé lentes nocturnos Swarovski NC2 (×4 de aumento) para registrar el tiempo de arribo de las bandadas y para estimar sus números. En los primeros 60 minutos después del ocaso se notaron muy pocos arribos. Un incremento significativo de ellos se notó 90–150 min. posteriormente al ocaso. Ningún azor del mediterráneo oriental fue observado arribando después de 180 min post-ocaso. El aviso previo de los números que arribaban a las perchas, permitió al equipo de captura organizar adecuadamente el dispositivo de captura, y durante el periodo de estudio un total de 368 azores del mediterráneo oriental fueron atrapados. Los datos representan la primera vez en que rapaces migratorias han sido observadas e identificadas de cerca con unos lentes de visión nocturna, arribando un sitio percha.

[Traducción de César Márquez]

of the N2 night scope for this and other nocturnal studies. R. Spaar, P. Kerlinger, K. Bildstein, and an anonymous reviewer improved an earlier version of the manuscript.

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NESTING DISTRIBUTION, FOOD HABITS, AND CONSERVATION OF OSPREY ON BOAVISTA ISLAND (ARCHIPELAGO OF CAPE VERDE)

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The Osprey (*Pandion haliaetus*) is widely distributed around the world and it has suffered heavily from several

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human impacts such as persecution, disturbances, and fishery practices (Saurola and Koivu 1987). This raptor eats live fish almost exclusively (Häkkinen 1977, 1978, Saurola and Koivu 1987) and therefore its distribution is restricted to the vicinity of favorable fishing waters; e.g., rivers, lakes, and sea coasts (Poole 1989).

In ideal conditions Osprey nests are located close to

the shoreline. However, timber extraction and shoreline development have reduced the availability of suitable nesting sites, likely causing population declines (Ewins 1997). Because Ospreys are generally wary in areas disturbed by human activities, they may locate their nest several kilometers from foraging areas (Saurola 1997). Nevertheless, in many areas, Ospreys have adapted to intensive human activity by nesting on powerline poles, windmills, bridges, and other structures (Cramp and Simmons 1980, Ewins 1997, Saurola 1997).

Naurois (1969) estimated 50 pairs of Osprey inhabited the Cape Verde Islands during the 1960s. Through the years, this population has remained about the same size, with 3–8 pairs on each island and 1–2 pairs on the islets (Hazevoet 1995). However, Ferreira and Palma (2000) described a general decline of this population due to persecution and human pressure, which has caused abandonment of several accessible nests (only 31–38 breeding pairs reported in 1998). Apart from this information, there is a study on Ospreys in Cape Verde (Naurois 1987); but the diet, nesting distribution, and specific conservation problems of the population on the island of Boavista have never been analyzed. Traditionally, this Osprey population has remained stable because this island was unknown to travelers (Naurois 1969, Hazevoet 1995). Also, Boavista has been only sparsely populated by humans for centuries. However, the plans for the future tourist expansion will increase human disturbances and may threaten the species. In this paper, I examine the population, nesting distribution, characteristics of the nests, food habits, and the possible influence of tourist activities in the Osprey population on Boavista Island.

STUDY AREA AND METHODS

The Cape Verde Islands are situated in the eastern Atlantic between 14°48′–17°22′N and 22°44′–25°22′W, 460–830 km west of Senegal (Fig. 1). There are 10 islands and several islets. Boavista Island is the third largest island of the archipelago, 620 km² in area with a perimeter of 116 km. The topography is generally flat, the highest elevation (Monte Estância) being only 387 m, and very dry (mean annual rainfall for Boavista is 91 mm [Kasper 1987]). Because the moderating influence of the surrounding ocean temperatures are relatively constant, the amplitude of mean temperatures in different months is seldom more than 6°C. Large areas are covered with sand, forming mobile dunes and barren stony plains, but in the interior there are oases with palms (Sena-Martins et al. 1986).

For this study, I gathered preliminary data on the Boavista Osprey population from island people and naturalists. Because Osprey breeding sites are usually close to water (Ewins 1997, Saurola 1997), I conducted transects by vehicle and on foot close to the shoreline during 1999 (total transect length = 121.2 km). Each time I detected an Osprey, I stopped the vehicle and searched by foot for nests and perches.

To analyze the Osprey diet in July 1999, I collected prey remains and pellets from nests and perches (Häk-
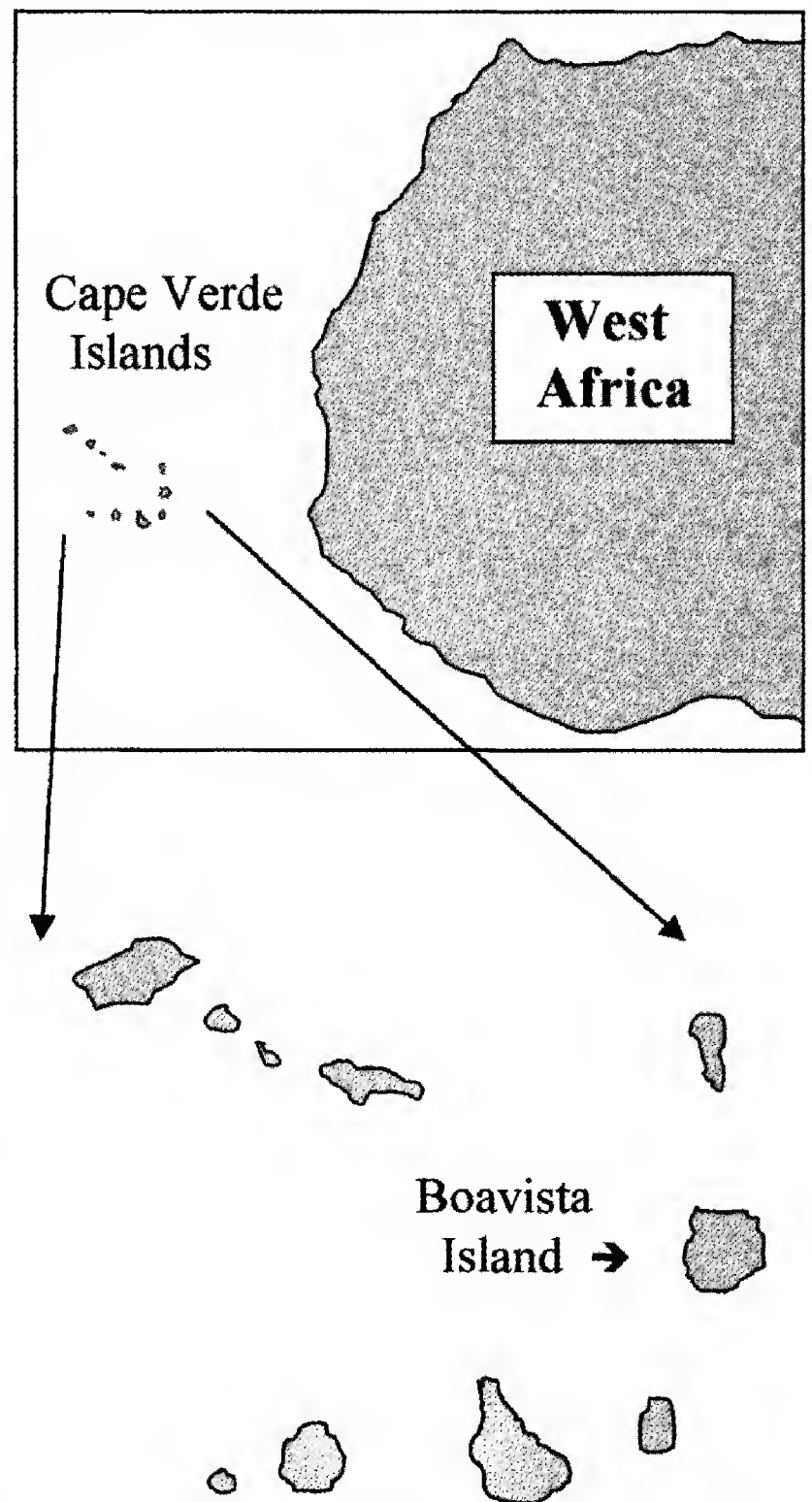

Figure 1. Map of Cape Verde Islands, and their position relative to West Africa.

kinen 1978) used by five different pairs. All pellets and 95.4% of the remains were collected near perches, and the rest of the prey remains came from nests. The prey items were identified to the species level (when possible) by comparing them with a local reference collection and fish-identification guides (Muus and Dahlstrøm 1971, Rojo 1988, Muus et al. 1999). Finally, I contacted with the Cape Verde Authorities and the Cape Verde Nature 2000 project coordinator, for information on current and planned tourism development and research projects for Boavista Island.

RESULTS AND DISCUSSION

The Osprey population of Boavista is composed of at least eight pairs that are distributed regularly along the

Table 1. Diet of the Osprey on Boavista Island (Cape Verde).

PREY	FREQUENCY OF PREY	PERCENT FREQUENCY
Parrotfish	127	89.4
Salemas	2	1.4
Bennett's flying fish	2	1.4
Dentex	5	3.5
Trachichthydae	1	0.1
Unidentified fish	5	3.5
Total	142	

shoreline. The mean distance between nests was 12.6 ± 2.1 km (range = 10.5–16.5 km; distance between pairs measured as km of coast from the nests of neighboring pairs). On Boavista Island, trees are practically non-existent and, thus, Ospreys normally occupy other nest sites. I found nests on small cliffs ($N = 7$), on the mast of a beached boat ($N = 1$), on the ground ($N = 2$), on the ground on a small islet ($N = 1$), and one nest on a palm-tree (*Phoenix* sp.).

The occupied Osprey breeding sites in Boavista Island are close to the shoreline, at a mean distance of 134.8 ± 306.7 m from the water (range = 0–950 m; $N = 8$). This location minimizes energy expenditure (Garber 1972, Henny et al. 1978, Ewins 1997) for Ospreys, which generally forage on the coastline.

The availability of suitable nest sites may be limiting local breeding populations (Newton 1979, Ewins 1997) as I found few structures suitable for supporting nests during my survey. The number of Ospreys in Boavista probably has remained stable during the last few years, but increased tourism on this island may eventually cause a population decline (Ferreira and Palma 2000). I found that the two nests on the ground, which were vulnerable to disturbance, did not have prey remains indicating no recent use. Therefore, the scarcity of alternative nesting cliffs and the human disturbance of some existing nest sites may be a threat to the future of this population.

As Ospreys clean and tear the fish before eating them (Moll 1962), only 11 pellets were found in the study area. These pellets corresponded to 11 prey, and the rest of information on food habits came from collected remains. Six different types of prey were identified among the 142 prey items found in the study area (Table 1). The abundance of *Sparisoma* sp. in the diet of this raptor on Boavista Island is notable. This genus is the most abundant among the medium-size fish around this island, thriving in water up to 2 m deep (Ontiveros unpubl. data), near the surface, where Osprey usually catch their prey (Poole 1989). This agrees with the fact that Osprey takes the most abundant available prey in each moment (Edwards 1988, Poole 1994). However, my data were in opposition to Bannerman and Bannerman (1968), who described

the Osprey as having a wide choice of prey in the sea around the Cape Verde Islands and specified that *Serranus cabrilla* was the most important prey in this archipelago.

In the past, Ospreys were killed in Europe as a competitive consumer of fish (Dennis 1991, Saurola 1997). However, in Boavista the fishing is based on large fish species not consumed by Ospreys, such as tuna (*Thunnus thynnus*); thus, this raptor has not been considered as a competitor by the people, the bird being traditionally respected. Nevertheless, Osprey eggs and nestlings are consumed by people as food on some Cape Verde islands (Ferreira and Palma 2000).

The conservation needs of island fauna, and especially of raptors, are generally more urgent than those of continental species, except where limited distributions on continents mimic an island situation (Virani 1995, Virani and Watson 1998). The Cape Verde Osprey population has recently been estimated at 31–38 pairs (Ferreira and Palma 2000) and, as on Boavista Island, tourism projects on many islands of the archipelago represent a threat to the entire island population. The Cape Verde government is promoting projects to boost tourism in the country in two ways: (1) building tourist centers in undisturbed coastal habitats and (2) favoring such activities as watching marine turtles, especially the loggerhead sea turtle (*Caretta caretta*), the most abundant turtle in the sea surrounding Boavista Island (López-Jurado et al 1999).

The Osprey is easily detected on the shoreline of the island and can also be a tourist attraction in the area Nevertheless, the current increasing human population threatens the Osprey population on the island and probably on other islands of Cape Verde. In other places in the world, the stabilization of Osprey breeding habitats has been due largely to intensive management, including nest-site protection (Poole 1989, Spitzer 1989, Houghton and Rymon 1997), which has been proposed for Ospreys on the Cape Verde Islands (Ferreira and Palma 2000). If Ospreys are not persecuted, they tolerate human activities quite well (Houghton and Rymon 1997, Saurola 1997). A growing number of adventure lovers and eco-tourists are expected to visit this desertic island in the next years; maintaining a buffer area surrounding nests free of human disturbances during the breeding period (especially for the most accessible nests), could help to conserve the Osprey population while permitting the tourist activities in the archipelago. Efforts in this direction can serve to make the conservation of Boavista wildlife compatible with economic expansion on the island

RESUMEN.—La distribución y dieta del Águila Pescadora (*Pandion haliaetus*) fue estudiada en la Isla de Boavista (archipiélago de Cabo Verde) durante 1999 a través de transectos lineales en vehículo y a pie, así como las amenazas existentes sobre la población. Se localizó una población uniformemente distribuida a través del perímetro de la isla, con una distancia media entre las 8 parejas

encontradas de 12.6 ± 2.1 km. Debido a la escasez de vegetación de la isla y la exigua población humana, el Águila Pescadora nidificó en lugares tan variados como roquedos, islotes, el mástil de un barco encallado, una palmera, y el propio suelo. Los nidos se ubicaron invariablemente cerca de la orilla del mar, con una distancia media entre el nido y el agua de 134.8 ± 306.7 m, minimizando de esta forma el gasto energético de las aves en sus desplazamientos. El 89.4% de las presas capturadas fue *Sparisoma* sp., uno de los géneros de peces más abundantes en aguas somera. Para evitar la influencia del turismo creciente, es conveniente diseñar un plan de protección para la isla que lo haga compatible con la conservación de la especie.

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RED-SHOULDERED HAWK AND APLOMADO FALCON FROM QUATERNARY ASPHALT DEPOSITS IN CUBA

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KEY WORDS: *Aplomado Falcon*; Falco femoralis; *Red-shouldered Hawk*; Buteo lineatus; *Antilles*; *Cuba*; *extinctions*; *fossil birds*; *Quaternary*; *West Indies*.

The fossil avifauna of Cuba is remarkable for its diversity of raptors, some of very large size, both diurnal and nocturnal (Arredondo 1976, 1984, Suárez and Arredondo 1997). This diversity continues to increase (e.g., Suárez and Olson 2001a, b, 2003a) and many additional species are known that await description. Not all of the raptors that have disappeared from Cuba in the Quaternary are extinct species, however. We report here the first records for Cuba of two widespread living species that are not known in the Antilles today.

These fossils were obtained during recent paleontological exploration of an asphalt deposit, Las Breas de San Felipe, which is so far the only "tar pit" site known in the West Indies. Two fossiliferous localities known as San Felipe I and II occur among extinct and active tar seeps in the floor of the San Felipe Valley, Matanzas Province, 5.5 km west of the town of Martí (ca. 22°57′N, 80°58′W; sheet Martí 4084-IV, 1:50 000 map, X502, Y347; map published in 1986 by the Instituto Cubano de Geodesia y Cartografía). The age of the deposits is Quaternary, probably late Pleistocene and early Holocene (Iturralde-Vinent et al. 1999, 2000). Although the fossil record of birds in Cuba has hitherto been biased by the fact that almost all specimens have come from cave deposits, the tar seeps of San Felipe provide a much better sample of open-country and aquatic birds that seldom or never are preserved in caves. The list of taxa is extensive and includes among other taxa cranes (*Grus*), thick-knees (*Burhinus*), storks (Ciconiidae), waterfowl (Anatidae), crows (*Corvus*), with a diverse variety of raptors and scavengers being especially abundant (Iturralde-Vinent et al. 2000, Suárez 2000, Suárez and Olson 2003a, b, Suárez unpubl. data).

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MATERIAL EXAMINED

Fossils are from the collections of the Museo Nacional de Historia Natural, La Habana, Cuba (MNHNCu). Modern comparative skeletons included specimens of all of the species of *Buteo* and *Falco* in the National Museum of Natural History, Smithsonian Institution, Washington, DC (USNM). The following specimens were used for the tables of measurements: *Buteo lineatus* 16633–16634, 17952–17953, 18798, 18846, 18848, 18965, 19108, 19929, 290343, 291174–291175, 291197–291200, 291216, 291860–291861, 291883, 291886, 296343, 321580, 343441, 499423, 499626, 499646, 500999–501000, 610743–610744, 614338; *Falco femoralis* 30896, 291300, 319446, 622320–622321.

Family Accipitridae
Genus *Buteo* Lacepede
Red-shouldered Hawk *Buteo lineatus* (Gmelin)
(Fig. 1 A–C)

REFERRED MATERIAL

Proximal end of right femur (MNHNCu P4614), distal halves of right and left tibiotarsi (MNHNCu P4615, MNHNCu P4616), distal end of left tibiotarsus (MNHNCu P4617) and distal halves of right and left tarsometatarsi (MNHNCu P4618, MNHNCu P4619). Collected in November 1988 by Manuel Iturralde-Vinent, Reinaldo Rojas-Consuegra, and Stephen Diaz-Franco at San Felipe II.

COMPARISONS

In size and proportions, these specimens agree with the Red-shouldered Hawk (*Buteo lineatus*) (Table 1), being larger than the Broad-winged Hawk (*B. platypterus*) and smaller than the Red-tailed Hawk (*B. jamaicensis*), the only two species of *Buteo* that are year-round residents in Cuba today (Garrido and García Montaña 1975). As was the case with fossils from the Bahamas, we took pains to compare the specimens with skeletons of Gray Hawk (*B. nitidus*), a widespread species of open country that is of approximately similar size and that might be expected to have occurred in the West Indies. But skeletal elements of *B. nitidus* are consistently more robust than in *B. lineatus*.

Figure 1.   A–C, modern Red-shouldered Hawk, *Buteo lineatus* (USNM 17953, on the left in each pair) compared with Cuban fossils of the same species (A, MNHNCu P4614; B, P4615; C, P4618). D–E, modern Aplomado Falcon, *Falco femoralis* (USNM 291300, on the left in each pair) compared with Cuban fossils of the same species (D, MNHNCu P4606; B, P4609). A, proximal end of right femur in anterior view; B, distal end of left tibiotarsus in anterior view; C, distal end of right tarsometatarsus in anterior view; D, right carpometacarpi in internal view; E, left tarsometatarsi in anterior view. Scale bars = 2 cm.

Table 1. Skeletal measurements (mm) of Cuban fossil and modern Red-shouldered Hawk (*Buteo lineatus*).

MEASUREMENT	CUBAN FOSSILS			MODERN		
	RANGE	MEAN	N	RANGE	MEAN	N
Femur						
Depth of head	4.9		1	4.5–5.7	5.1	33
Tibiotarsus						
Least width of shaft at midpoint	5.6		1	4.8–6.1	5.5	33
Distal width through condyles	9.9–10.9	10.4	2	9.5–11.7	10.9	33
Tarsometatarsus						
Least width of shaft at midpoint	4.9		1	3.7–5.0	4.4	31
Width of shaft proximal to metatarsal facet	5.1–5.3	5.2	3	4.1–5.8	5.1	32
Depth of shaft proximal to metatarsal facet	4.2–4.4	4.3	2	3.4–4.4	3.9	32
Distal width	12.3		1	11.2–13.3	12.3	32
Depth of middle trochlea	4.9		1	4.4–5.3	4.9	32

REMARKS

Although the Red-shouldered Hawk now has an entirely continental distribution, it has previously been known in the West Indies from a few fossils from cave deposits in the Bahamas (Olson 2000), where it first was described as an endemic genus and species *Calohierax quadratus* (Wetmore 1937, but see Olson and Hilgartner 1982, Olson 2000). Thus, its occurrence in Cuba might have been predicted. The Bahaman population was probably derived from that of Cuba, as has been the case with many other birds (Brodkorb 1959, Olson and Hilgartner 1982).

The Red-shouldered Hawk is ordinarily a species of mesic bottomland forests, so its withdrawal from Cuba and the Bahamas is difficult to understand in light of the fact that ecological conditions in these islands presumably have become more mesic since the end of the last glacial period. Potential sources of food were much greater in Cuba than in the Bahamas, making the disappearance of this hawk from Cuba even more enigmatic.

The Red-tailed Hawk and the Broad-winged Hawk, each represented by supposedly endemic subspecies (*B. jamaicensis solitudinis* Barbour and *B. platypterus cubanensis* Burns), are common on Cuba today (Raffaele et al. 1998, Garrido and Kirkconnell 2000) and both have been recorded from Quaternary cave deposits on Cuba (Jiménez 1997, Suárez and Arredondo 1997), with the latter being found in the San Felipe II asphalt deposits as well (Suárez unpubl. data.). It hardly seems likely that the disappear-

ance of the intermediate-sized Red-shouldered Hawk from Cuba could be related to the disappearance of prey, which would presumably have affected the other species of *Buteo* as well.

Ridgway's Hawk (*Buteo ridgwayi*), endemic to Hispaniola, is now believed to be a small derivative of *B. lineatus* (Olson 2000). The prehistoric occurrence of the latter in Cuba suggests that the ancestral stock of Ridgway's Hawk was probably derived from insular populations of *B. lineatus*, and most likely from Cuba.

Family Falconidae
Genus *Falco* Linnaeus, 1758
Aplomado Falcon *Falco femoralis* Temminck, 1822
(Fig. 1 D–E)

REFERRED MATERIAL

Right carpometacarpus lacking minor metacarpal (MNHNCu P4606), right carpometacarpus lacking distal end and minor metacarpal (MNHNCu P4607), distal end of left tibiotarsus (MNHNCu P4608), proximal end of left tarsometatarsus (MNHNCu P4609), collected 25 February 2001 by Stephen Díaz-Franco and William Suárez at San Felipe I, area C.

COMPARISONS

These specimens agree perfectly in size and characters with the Aplomado Falcon (*Falco femoralis*) (Table 2). They are much too large for American Kestrel, Merlin, or Bat Falcon (*F. sparverius, F. columbarius, F. rufigularis*)

Table 2. Skeletal measurements (mm) in fossil and modern Aplomado Falcon (*Falco femoralis*).

MEASUREMENT	CUBAN FOSSILS			MODERN		
	RANGE	MEAN	N	RANGE	MEAN	N
Carpometacarpus						
Total length	41.8		1	37.7–42.5	40.8	4
Proximal width	4.6*		1	4.4–5.1	4.7	4
Proximal depth	10.8		1	9.1–11.6	10.7	4
Width of major metacarpal at midpoint	3.5–3.6	3.5	2	2.9–3.6	3.3	4
Tibiotarsus						
Distal width	7.5[a]		1	7.0–8.7	7.9	5
Tarsometatarsus						
Width at level of proximal foramina	6.4		1	5.7–7.0	6.5	5

[a] Estimated.

or for the extinct Cuban species *F. kurochkini* (Suárez and Olson 2001a), and too small for a Peregrine (*F. peregrinus*) or Prairie falcon (*F. mexicanus*). No skeletons were available for Orange-breasted Falcon (*F. deiroleucus*), but this species has very different proportions from *F. femoralis*, with a proportionately shorter and much more robust tarsometatarsus.

REMARKS

That the Aplomado Falcon once occurred in Cuba is perhaps not unexpected. It is a partially migratory species with an extremely wide range extending from the southwestern United States to Tierra del Fuego and the Falkland Islands. It inhabits shrub grasslands and savanna and there is increasing evidence of various species of birds adapted to such conditions in the Quaternary of Cuba. This is the first indication of the species anywhere in the West Indies.

RESUMEN.—Procedentes de depósitos cuaternarios de asfalto en San Felipe, al norte de la Provincia de Matanzas, se registran por primera vez para Cuba dos especies de rapaces que viven hoy en el continente: *Buteo lineatus* y *Falco femoralis*; este último constituye la primera evidencia de ese taxon en la Subregió n Antillana.

[Traducción de los autores]

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SUBADULT AND PALE STEPPE EAGLES BREEDING IN MONGOLIA

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All adult Steppe Eagles (*Aquila nipalensis*) are reportedly very dark (Ferguson-Lees and Christie 2001). However, the closely related (Wink and Sauer-Gürth 2000) Tawny Eagle (*A. rapax*) does have a pale adult morph (see Plate 114, Brown and Amadon 1968). Clark (1992) decried the confusion in the scientific literature and in museum collections over the various morphs of the Steppe and Tawny eagles and advanced "criteria for the correct identification of all museum specimens and live birds . . . ." He states conclusively that Steppe Eagles become "much darker as adults." His assertion stems from fieldwork in Israel, India, and Africa, and, more importantly, from handling over 300 museum specimens. His conclusion reaffirms statements by Cramp and Simmons (1980) that subadults are paler than adults and that all very pale birds are young.

While it is helpful to examine migrants and wintering birds in evaluating the prevalence of adult morphs, evidence to support the claim that no adults are pale must come from the breeding grounds. Even there, if very pale breeders are found, it is necessary to determine if re-

placement (i.e., newly grown) feathers are light or dark before concluding that the Steppe Eagle has a pale adult morph. Although subadults of some species of *Aquila* eagles are known to at least occasionally breed (e.g., Newton 1979, Steenhof et al. 1983), I know of no prior record of a subadult Steppe Eagle breeding.

During five expeditions to Mongolia from 1994–2000, I found more than 20 Steppe Eagle nests. At one site in arid southeastern Mongolia (115°E, 45°N), we found a very pale bird (Fig. 1). Elsewhere we found two rufous-plumaged birds. All three were attending live young. One of the rufous birds was captured (Ellis et al. 2001) and photographed in hand. The very pale bird was photographed on its nest at a distance of 2 m.

In Mongolia, Steppe Eagle adults are generally deep chocolate brown above and below with blackish remiges and rectrices finely barred with black. These dark birds match Clark's (1992, 1996) descriptions of the dark brown adult plumage. The only consistently present light area in the plumage of dark adults is a broken line of whitish spots on the upper tail coverts. This line is readily visible at great distances when a bird is flying, except when overhead. Some dark birds (probably those molting from subadult plumage) show a dappled line of light brown at the trailing edge of the under wing coverts. Under some light conditions, pale areas at the base of the primaries are apparent on the underside of the wings of some, and probably all, dark adults. The head is gen-

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Figure 1.   Pale Steppe Eagle at its nest in southeastern Mongolia. This bird resembles the adult pale morph of the Tawny Eagle as illustrated by J. Harrison (Brown and Amadon 1968:649) and appears identical to a pale subadult or adult Tawny Eagle photographed at the nest by P. Steyn (1973:54–55). Note metal trash in nest, a conspicuous, and sometimes dangerous, feature of Steppe Eagle nests across Mongolia (Ellis and Lish 1999). The lower photo includes a hatchling and 1 egg. This photo also shows two generations of feathers (most conspicuous in the anterior scapulars), feathers of both generations are worn (suggesting that this bird is at least 2 yr old) and both are very light (demonstrating that in this individual light plumage was retained). The upper photo shows pale tips on rectrices, "tertials," and secondaries, a characteristic common to all juvenile Steppe Eagles. This bird fits Clark's (1992) gray-brown morph, frequently seen in Steppe Eagles for the first 3 or 4 yr.

erally uniformly dark, but, as stated by Cramp and Simmons (1980), some birds show light (buff) hackles on the nape or back of the head. One extremely pale-headed, but otherwise dark, adult from central Mongolia was observed at close range while it perched on the nest rim. It displayed a light area on its head and nape just as pale as in most adult Golden Eagles (*A. chrysaetos*).

In contrast to the extremely dark adults that are typical for Mongolia, our blond breeder (Fig. 1) was uniformly pale buff on the whole mantle, head, and upper wing coverts. Only the remiges, rectrices, and distal scapulars were heavily pigmented. Even though the rectrices and secondaries were dark, they showed pale tips and pale basal barring and were, therefore, much lighter than those of dark adults. W. Clark (pers. comm.) compared photographs of this bird with his published descriptions of various age classes (Clark 1992, 1996) and concluded that this bird was subadult. Indeed, it closely matches the third/fourth-year Steppe Eagles illustrated by Ferguson-Lees and Christie (2001).

The key plumage features leading to the conclusion that the bird was not adult are the pale tips of the rectrices and secondaries, very evident in the photographs (Fig. 1). In the pale morph of the Tawny Eagle, extensive pale tips reportedly are present only on juveniles. However, Steyn (1973) photographed a breeding, pale morph Tawny Eagle with pale tips of secondaries and rectrices just as seen in our pale bird from Mongolia. Further, Ferguson-Lees and Christie (2001) illustrate the pale morph adult Tawny Eagle with pale tips. Hence the confusion: was this bird a subadult breeder or do both species have extremely pale adults which show broad, light tips to the rectrices and secondaries? However, the rarity of records of blond Steppe Eagles breeding (i.e., this is the only record now documented) strongly suggests that the pale bird was not an adult.

Our two intermediate morph breeders match the rufous-tawny, subadult morph described by Clark (1992). As such, these two records substantiate breeding in subadult plumage and add the Steppe Eagle to the list of *Aquila* eagles that breed in subadult plumage. However, there is a remote possibility that the refous-tawny eagles and the blond eagle may have been replacement birds (Phillips et al. 1991), not the biological parents of the young in the nests.

RESUMEN.—Una forma pálida y dos oscuras de águila de las estepas (*Aquila rapax*) fueron observadas en medio de 20 parejas encontradas anidando en Mongolia. Todas las tres estaban cuidando juveniles vivos. Las características del plumaje de las aves de color café rojizo—tostado sugieren que no eran adultos. En consecuencia la anidación de subadultos del águila de las estepas (*Aquila nipalensis*) es documentada. La anidación también se documentó para un ave de fase pálida, pero la edad de esta ave es incierta; tampoco se sabe si esta era la primera forma pálida adulta conocida para la especie o, si mas

probablemente, esta representa un ave reproductora de 2-, 3-, o 4 años de edad.

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TWO LARGE BALD EAGLE COMMUNAL WINTER ROOSTS IN UTAH

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KEY WORDS: *Bald Eagle;* Haliaeetus leucocephalus; *migration; roost; Utah; winter.*

As migratory birds, many Bald Eagles (*Haliaeetus leucocephalus*) breed in the northern portions of the species' range, and winter in the southern portions (Stalmaster 1987). The location of a particular breeding range is a good predictor of the location of the winter range and the corresponding migratory route. Such associations of winter and summer ranges have been documented in Maine (McCollough 1989), central Canada and U.S. (Gerrard et al. 1978, Griffin et al. 1980, Harmata and Stahlecker 1993), Alaska (Hodges et al. 1987), and the Intermountain West (McClelland et al. 1994). Banding and tracking studies also discovered numerous examples of nesting area fidelity (Gerrard et al. 1978, Jenkins et al. 1999), and winter range fidelity (Gerrard et al. 1978, Harmata and Stahlecker 1993, McClelland et al. 1994). But such patterns are not rigid; nomadic behavior has also been documented (e.g., Postupalsky 1976, McClelland et al 1994, Jenkins et al. 1999).

Numerous studies have described interior populations of wintering Bald Eagles (e.g., Southern 1963, 1964, Knight and Knight 1983, Harmata and Stahlecker 1993, Restani 1997), and many focused on communal roosts (Edwards 1969, Keister and Anthony 1983, Harmata 1984, Isaacs and Anthony 1987, Crenshaw and McClelland 1989). But only a few studies (e.g., Swisher 1964, Edwards 1969) have examined communal roosts in Utah. The primary aim of this study is to provide occupancy dates, population estimates, locations, and habitat descriptions of two large (>200 eagles/night) communal roosts in northern Utah.

STUDY AREA

The Willard Canyon roost (WCR) is in the Willard Basin which expands to the southeast of the mouth of Willard Canyon (41°25′N, 112°00′W). Vegetation consists mostly of a Douglas-fir (*Pseudotsuga menziesii*) canopy, with an understory of ninebark (*Physocarpus malvaceus*), and some white fir (*Abies concolor*), subalpine fir (*A. lasiocarpa*), and limber pine (*Pinus flexilis*). This vegetation is consistent with the douglas-fir/ninebark community de-

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scribed by Mauk and Henderson (1984). The mouth of the canyon is 4 km from Willard Bay on the west shore of the Great Salt Lake, which has surface elevations near 1280 m. The Bear River delta is at or near the elevation of the Great Salt Lake and includes the Bear River Migratory Bird Refuge and surrounding area.

The Ogden Bay roost (OBR) is located in the Weber River delta (41°12′N, 112°9′W) on the west shore of the Great Salt Lake. The elevation of the delta is only slightly above the elevation of the Great Salt Lake. As a result of high water in the 1980s, numerous deciduous trees along the channels of the lower delta were killed by salt water invasion. Eagles roost in these snags, which are buffered by roadless wetlands nearly 1 km in radius. This site is ca. 23 km southwest of the WCR.

METHODS

The WCR had the highest occupancy of all roosts surveyed. Therefore, from the beginning of January to early April, 1998, and from the beginning of December 1998 to early April, 1999, we sampled this site systematically. We surveyed three times a week in the 1997–98 season and twice a week during the 1998–99 season; surveys were conducted from 1230 H until after sunset by one observer located near the mouth of the canyon. Early in the 1997–98 season, we also observed the site between first light and 1000 H. We used 10 × 42 binoculars and a 16–32 × 50 spotting scope to locate and identify eagles at a distance. The exact sampling location varied depending upon flight patterns, but the intersection of a private canal road with a gravel pit road was used most frequently. The roost itself could be observed from locations on the ridge north of the canyon from whence we could see the top of the West Fork drainage. When possible, eagles were classified by plumage, according to criteria described by Stalmaster (1987) and Wheeler and Clark (1995).

Because eagles that returned to the roost early in the afternoon would sometimes soar above the mouth of the canyon, we only counted eagles seen approaching from the direction of the daily activity centers (DACs). This reduced the chances of redundant counting of individuals.

The OBR was surveyed every other week during the 1997–98 season, and weekly during the 1998–99 season. However, no data were collected from OBR in March–April 1999. At the WCR, time of return was recorded in 30-min intervals before sunset.

RESULTS

Occupancy. During the winter of 1997–98, all sites except WCR had peak numbers in February (Figs. 1 and
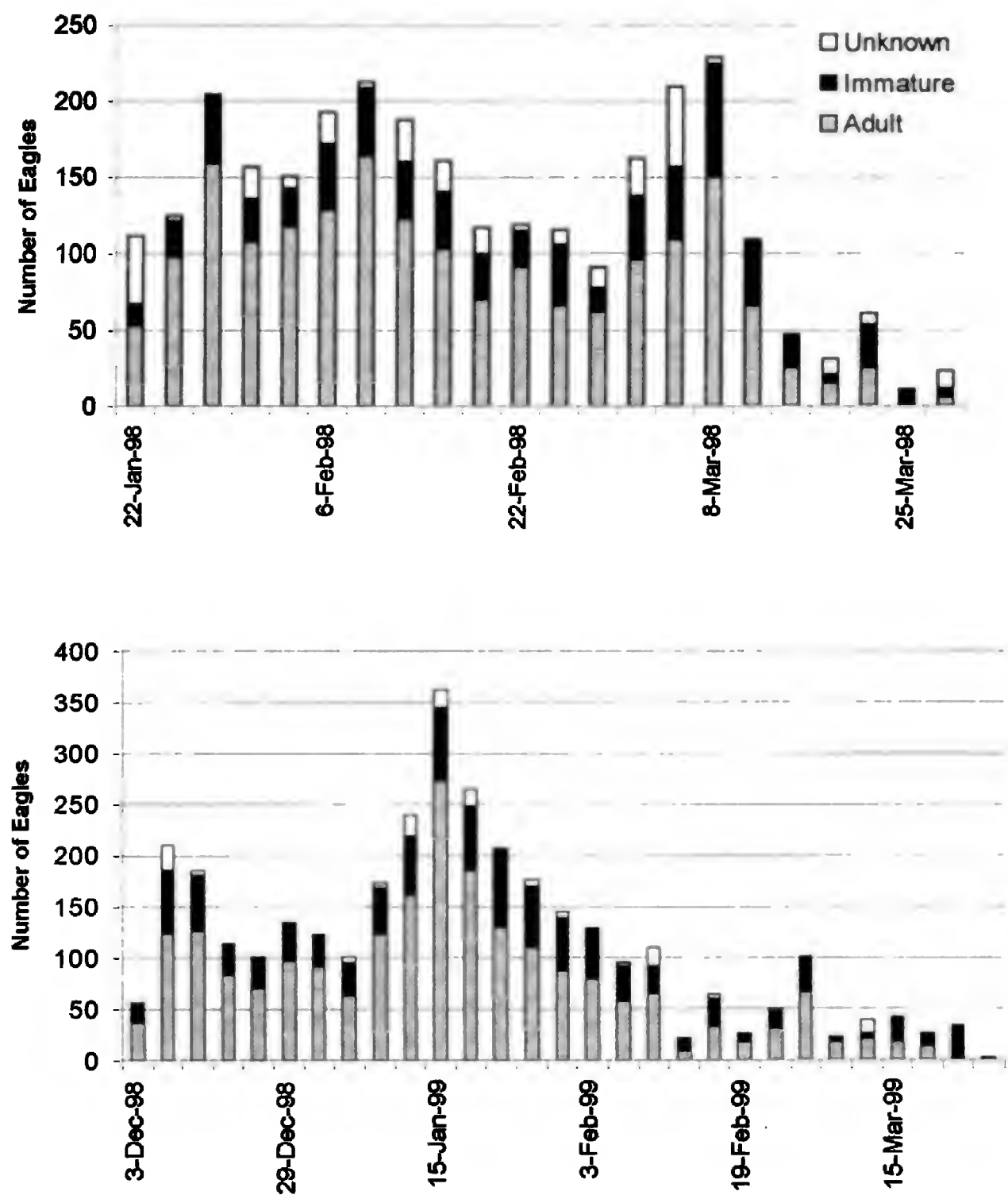
Figure 1. Number of Bald Eagles at Willard Canyon.

2), while the season high at the WCR of 227 eagles occurred 8 March. The mid-winter high of 212 occurred at the WCR on 8 February. This was followed by a decline to 91 preceding the brief influx of eagles in March, and then a sharp decline after the March peak (Fig. 1). Other roosts did not follow a bimodal pattern. The OBR had a season high of 153 eagles on 4 February, after which the number gradually declined to three on 18 April, the last sample (Fig. 2).

In the 1998–99 season surveys began 3 December. On this date 58 individuals were already present at WCR, and we saw two eagles enter the roost on 4 November. Numbers peaked to 211 individuals on 13 December, declined, and rose again to a season high on 15 January, when 363 occupied the roost (Fig. 1). Numbers then declined, with the exception of 3 March when 101 returned to the roost (Fig. 1).

Between 9 January and 18 February the number of eagles at the OBR increased from 48 to the season high of 264 (Fig. 2). Unlike the previous year, eagles appeared to shift from WCR to OBR (Fig. 3).

Age Composition. From January–March 1998, the maximum percentage of adults (87.5%) was recorded on 18 January and immatures (88.4%) on 4 March 1998 (Fig. 1). A decline in the percentage of adults began after 8 March. The maximum number of 167 adults was observed on 8 February and 119 immatures on 4 March. From December 1998–April 1999, the maximum percentage of adults (75.5%) was recorded on 15 January and immatures (94.1%) on 30 March (Fig. 1). The maximum number of 274 adults was observed on 15 January and 72 immatures on 15 January.

At the OBR, percentages between December 1997 and April 1998 peaked at 86.9% adults on 4 February and
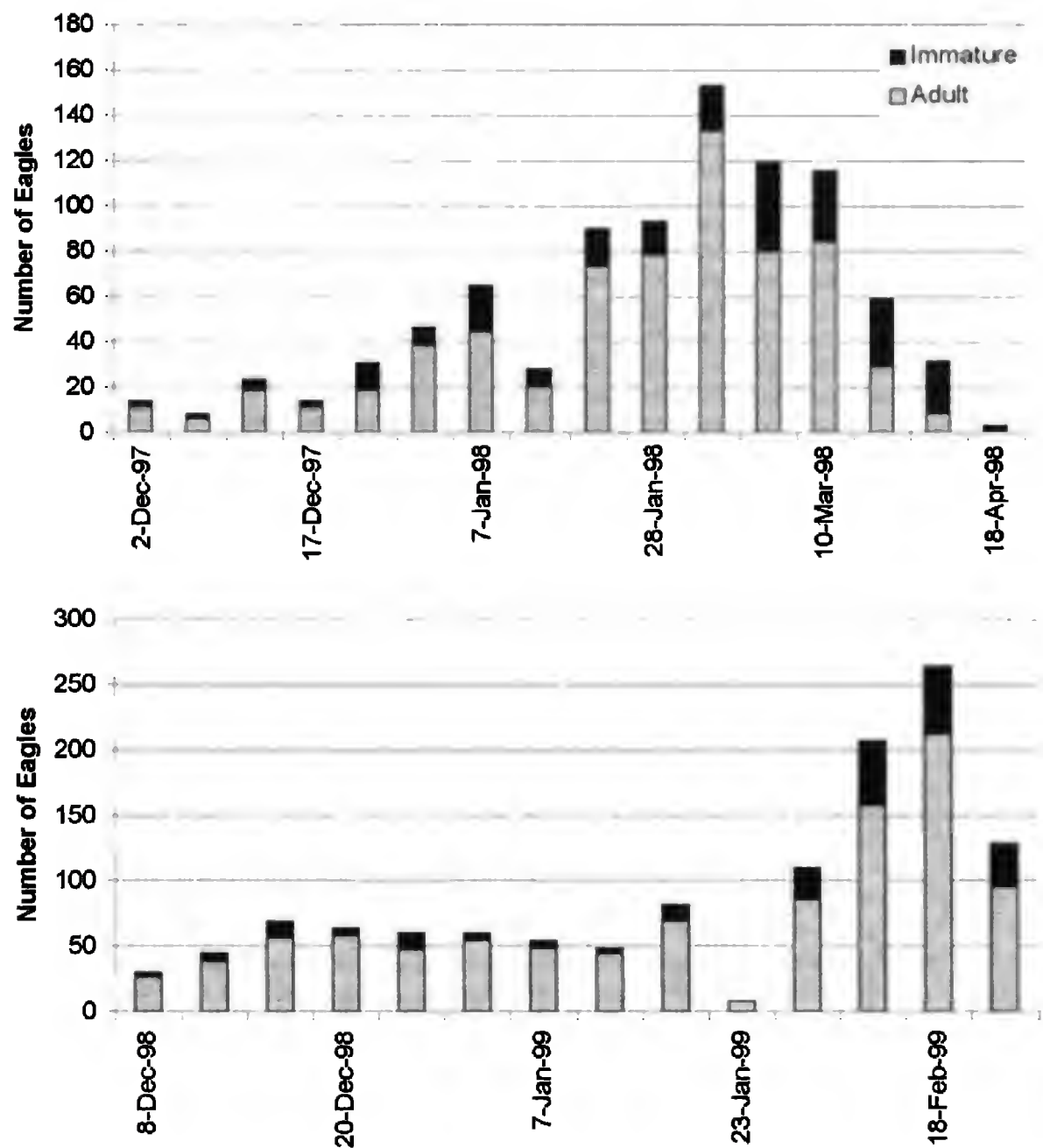
Figure 2. Number of Bald Eagles at Ogden Bay.
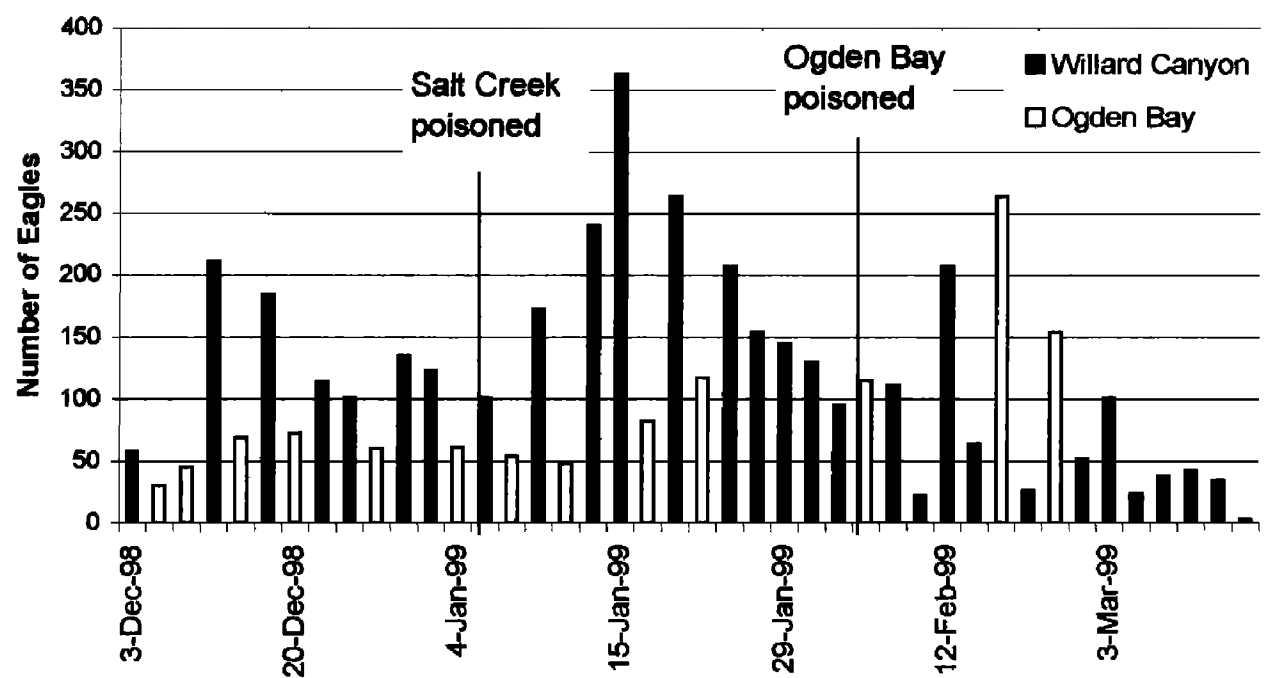
Figure 3. Comparison of eagle numbers using Willard Canyon and Ogden Bay (December 1998–March 1999).

100% immatures on 18 April. The percentage of adult birds at the OBR declined steadily after 10 March. The maximum numbers were 133 adults on 4 February and 39 immatures on 20 February (Fig. 2). During the 1998–99 season the maximum percentages at the OBR were 91.7% adults on 9 January and 23.6% immatures on 12 February. Numbers peaked at 212 adults and 52 immatures on 18 February (Fig. 2).

DISCUSSION

The roost habitat most likely to deteriorate in the near future is that of the OBR. No living trees exist in the roost area, and we detected no evidence of regeneration. Water management in the upper Weber drainage, in addition to fluctuating water and salt levels of the Great Salt Lake, result in unfavorable growing conditions for trees. Though riparian corridors with living trees exist upstream of the roost area, they are outside of the Ogden Bay Waterfowl Management Area boundaries, and subject to higher levels of disturbance.

The Willard Canyon roost is both the most heavily used and the most sheltered from human disturbance. We detected no evidence of habitat degeneration at this site, nor any threat of encroachment. This site is currently on U.S. Forest Service property and, because such large numbers of eagles use this roost consistently, its protection and maintenance should be ensured by Forest Service policy.

Changes in forage abundance also influence roost site selection. Both Edwards (1969) and Keister et al. (1987) observed that eagles tend to use the roost nearest the areas with highest prey densities, and that when prey densities changed, eagles selected different roosts accordingly. Shifts from WCR to OBR or elsewhere were not apparent during the 1997–98 season, but probably occurred during the 1998–99 season. Between 5 and 15 January 1999 the population of the WCR went from 191 to the season high of 363 eagles, then dropped to 22 by 11 February 1999. Conversely, between 9 January and 18 February the number of eagles at OBR increased from 48 to the season high of 264. Thus, the eagles appeared to shift from WCR to OBR. We suggest that water management at the eagles' daily-activity centers was the likely explanation for this change. The Bear River Migratory Bird Refuge drained its inner units during the first and second weeks of January trapping and exposing fish in shallow ponds and mudflats. Ponds at Salt Creek Waterfowl Management Area were drained in early January and rotenone was applied on 5 and 6 January (Fig. 3). These events corresponded with the influx of eagles into the WCR. This explanation is supported by the fact that eagles approached the roost mainly from the direction of Bear River Migratory Bird Refuge and Salt Creek Waterfowl Management Area. Water levels at Ogden Bay Wildlife Management Area were lowered during the first week of February, and on or near 8 February rotenone was applied to kill carp. Between 6 February and 18 February the number of eagles jumped at OBR from 115–264. This evidence strongly suggests a migration from one locally-abundant food source to another.

Availability of suitable habitat, such as that of the roosts described by Keister and Anthony (1983), Harmata (1984), and Restani (1997) probably explains the location of observed roosting habitat in northern Utah. The scarcity of roost habitat in close proximity to Bear River Migratory Bird Refuge and other suitable foraging habitat is apparent from the geography of the region. The mouth of Willard Canyon, 4 km from Willard Bay and the Great Salt Lake, is the closest portion of the Wasatch Mountains to suitable eagle foraging habitat. Furthermore, the top of Willard Basin is the largest basin in that portion of the Wasatch front. Canyons to the south have jagged, rocky sides, and do not open up into sub-alpine basins. Canyons to the north have origins in higher basins, but lack extensive evergreen cover. The canyons on the west slope of the Wellsville mountains (a ridge of the Wasatch beginning 12 km north of Willard Canyon) are steep, narrow, and lacking extensive evergreen coverage. The steep and rocky qualities of the lower portions of Willard Canyon make it difficult for human access when snow and ice are absent, and this canyon is essentially not accessible by people when winter conditions exist. We suggest that eagles would not make a 25 km daily commute to Bear River Migratory Bird Refuge (one way) if suitable roost sites existed closer to the foraging areas.

Thus, Willard Canyon has the appropriate suite of characteristics including location, altitude, topography, vegetation, and isolation that make it suitable as Bald Eagle roosting habitat. Likewise, the OBR is in the grove of trees closest to the foraging areas, and is insulated from human disturbance. Harmata (1984) cited the absence of disturbance as the primary factor in roost site suitability.

Eagles commuted to and from the roost daily, departing from the roost at first light, and returning from late morning until just after sunset, with rates of return increasing later in the afternoon. These patterns are similar to those described by McClelland (1973), Crenshaw and McClelland (1989), and others.

Unlike communal roosts in western Montana which are migratory stopovers used during early- and mid-autumn (Crenshaw and McClelland 1989, McClelland et al 1994), the Great Salt Lake is a migratory stopover for some individuals, and a southern terminus for others. This is evidenced by population spikes that suggest the passage of birds that winter farther south as well as continuous occupation by some birds between fall and spring migration. Crenshaw and McClelland (1989) observed that peak numbers and percentages of immatures occurred earlier than those of adults. We observed opposite patterns: maximum adult numbers and percentages occurred in mid-winter, while maximum immature numbers occurred later (except in March 1998 when maximum numbers of both adults and immatures occurred

on the same dates at WCR). Maximum immature percentages always occurred later than those of adults. Often small numbers of immatures were the last eagles to vacate a roost in the spring. Harmata (1984) documented similar patterns in the San Luis Valley, Colorado. McClelland et al. (1994) speculated that immatures delay spring migration into colder, northern breeding ranges because they cannot breed, and thus, have nothing to gain by migrating early in spring.

Occupation dates from early November to early April were very similar to those of winter-range communal roosts in central Utah (Edwards 1969, Platt 1976), in the San Luis Valley (Harmata 1984), and in the Klamath Basin (Keister et al. 1987). The numbers of eagles occupying either WCR or the OBR exceeded all other communal roosts documented in Utah. Occupation of roosts in northern Utah begins in early November, at the same time that eagles are vacating roosts in western Montana (Crenshaw and McClelland 1989, McClelland et al. 1994). Furthermore, McClelland et al. (1994) tracked more eagles to Utah from fall concentrations in western Montana, than to any state other than Montana. Many were tracked to the Great Salt Lake area, including Willard Bay. The correspondence of departure and arrival dates between western Montana roosts and northern Utah roosts, and the corroborating radiotelemetry information, provide evidence that northern Utah is a stopover or southern terminus for eagles in the "McKenzie-Intermountain Flyway" (McClelland et al. 1994). Furthermore, Harmata and Stahlecker (1993) and McClelland et al. (1994) documented multiple examples of winter site fidelity, including some in central Utah. The Willard Canyon and Ogden Bay roosts are among the largest known communal roosts in the lower 48 states, and the largest documented winter roosts within the McKenzie-Intermountain Flyway. They and their associated wetlands provide key habitat for Bald Eagles in interior-western North America.

RESUMEN.—Grandes números de águilas calvas (*Haliaeetus leucocephalus*) invernantes ocupan dos perchas comunales en el norte de Utah: la percha del cañón Willard y la percha de la bahía Ogden. Estas están entre las más grandes perchas comunales conocidas en los 48 estados inferiores, y es la más grande percha invernal documentada dentro de la vía de vuelo ínter montañosa McKenzie. Durante los inviernos de 1997–98 y 1998–99, estudiamos estos sitios- percha documentando su localización geográfica, hábitat, y ocupación. El Cañón Willard tuvo un numero máximo anual de 227 águilas en marzo de 1998 y 363 el 15 de enero de 1999. La percha de la Bahía Ogden tuvo un máximo de 153 águilas el 2 de febrero de 1998 y 264 hacia el 18 de febrero de 1999. Las águilas usaron estas perchas regularmente dentro de las estaciones y entre años.

[Traducción de César Márquez]

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LETTERS

FIRST BREEDING RECORD FOR *FALCO PEREGRINUS* IN URBAN LIMA, PERU, WITH REMARKS ON THE PERUVIAN BREEDING POPULATION

The Peregrine Falcon (*Falco peregrinus*) breeds on every continent except Antarctica, but is absent from large parts of some continents where they occur (most of Amazonia, Saharan regions of North Africa, and central China) and most islands of the Pacific Ocean. In South America the breeding distribution is incompletely known. Through the 1970s, the recorded breeding range for South American peregrines was thought to be from the southern tip of South America north to about 30–35°S (slightly north of Santiago, Chile) with densest known populations in extreme southern Chile, Argentina, and Falkland (Malvinas) Islands (Stresemann and Amadon 1979, Order Falconiformes. Pages 271–425 *in* E. Mayr and G.W. Cottrell [EDS.], Check-list of birds of the world, Vol. 1, 2nd Ed. *Mus. Comp. Zool.,* Cambridge, MA U.S.A.; Cade 1982, Falcons of the world. Comstock, Cornell Univ. Press, Ithaca, NY U.S.A.; and McNutt et al. 1988, Distribution and status of the Peregrine Falcon in South America. Pages 237–253 *in* T.J. Cade, J H. Enderson, C.G. Thelander, and C.M. White [EDS.], Peregrine Falcon populations: their management and recovery. The Peregrine Fund, Inc., Boise, ID U.S.A). Based on a pair at a cliff near Yauli, Peru, (3400 m elevation) on 10 September, a date prior to the arrival of Nearctic migrant peregrines, breeding was suggested (Morrison 1939, *Ibis* 81:453–486), then circumstantial evidence of breeding was found on a cliff ledge in 1979 near Tacna, Peru (Ellis and Glinski 1980, *Condor* 82:350–351), and later breeding in Peru was confirmed (Schoonmaker et al. 1985, *Condor* 87 423–424) as it was also confirmed into Ecuador (Jenny et al. 1981, *Condor* 83:387). Therefore, the map of breeding distribution in South America was radically changed by McNutt et al. (1988), so that rather than distribution stopping at about 30–35°S as in most map renditions, the distribution was extended northward along South America west of the Andes Mountains into Ecuador to a latitude near the equator. In fact, in Ecuador, peregrines had been found breeding at Yanayacu as early as 1877, but the record lay hidden in the literature (White 1989, *Condor* 91:995–997) The number of known breeding locations in Peru has increased in the past two decades, perhaps because of a greater search effort, but also there may have been a numerical increase in falcons (Kéry 2002, *J. Raptor Res.* 36:213–217), there are no data to suggest that the South American (Peruvian) populations were reduced or significantly negatively affected by synthetic chemicals (e.g., DDT) (Walker et al. 1973, *Antarctic J.* 8:29–31) as they were in North America.

In addition to local breeders, high number of migrant non-breeding Nearctic peregrines from both the tundra (*F p tundrius*) and boreal forests (*F. p. anatum*) occur throughout South America, especially along coastal regions and in large populated urban regions during austral spring and summer months (Albuquerque 1978, *Rev. Bras. Biol.* 38: 727–737; Risebrough et al. 1990, *Rev. Bras. Biol.* 50:563–574; Silva e Silva 1996, *Pap. Avulsos Zool., São Paulo* 39:249–270; and Silva e Silva 1997, *Ararajuba* 5:203–208). While there is extensive use of cities by peregrines they do not remain to breed there. Elsewhere, however, peregrines bred occasionally in urban areas of Europe, North America, Australia, and Africa before organochlorine pesticides became extensively used (Cade et al. 1988, Peregrine Falcon populations: their management and recovery. The Peregrine Fund, Inc., Boise, ID U.S.A.; and Cade et al. 1996, Peregrine Falcons in urban North America. Pages 3–13 *in* D. Bird, D. Varland, and J. Negro [EDS.], Raptors in human landscapes. Academic Press, New York, NY U.S.A). In South America the only previously-known, urban breeder was a pair nesting at a church in the center of Córdoba city, Argentina, in 1981–82 (R. Stranek pers. comm., C. White pers. observ.).

With the banning of DDT in the Northern Hemisphere, and as peregrines began to increase there, they invaded urban regions with increasing frequency largely as a result of the release of captive-bred birds which apparently recognized cities as appropriate breeding locations, perhaps related to their early captive experiences (Cade et al. 1996, D. Rockenbauch 1998, Der Wanderfalke in Deutschland. Verlag Christine Hölzinger, Ludwigsburg, Germany). But also the invasion into urban environments began to occur, for whatever reason, in regions where peregrines were not reduced by pesticides and where captive-bred birds were not released, such as in most urban centers in Australia (P Olsen pers. comm.), and our Peruvian nesting fits that pattern.

Today, resident peregrines are not uncommon in coastal Peru, and they are also observed in interior Peru. While increasing numbers of falcons are sighted during the Austral winter, sightings which exclude wintering non-breeding Nearctic peregrines are also more frequent. For example, in river valleys of central coastal Peru, three pairs were found with nestlings in July 1993. Two pairs produced four young each and a third had three fledglings on 18 July

(0. Beingolea pers. observ.). In July 1994, two of these pairs raised four young each. A third site inhabited by a pair was not visited. Although large portions of the Peruvian Andes have not been searched, it is likely that the finding of these pairs suggests that the breeding range for peregrines occurs along the entire Andean chain into central Ecuador. It is not known if they extend along the Andes beyond Ecuador or into the Cordillera Central and Oriental of Colombia and Cordillera de Merida of Venezuela; these areas have been extensively surveyed by ornithologists and it appears doubtful.

With this increase, peregrines have moved into urban Lima city. In the first week of June 2001, Beingolea was told about a pair of hawks that were excreting on the walls of the skyroom of the abandoned 20-floor, former Hotel Crillon in downtown Lima. Beingolea visited the building and confirmed the presence of a female peregrine beside a cavity, caused by the removal of a large cement block on the upperside of a window's roof, just below the hotel's 20th floor skyroom.

On 2 July 2001, Beingolea visited the building again and found a male peregrine incubating a single egg; the female was nearby eating a Rock Dove (*Columba livia*). On 8 August, he visited the building and found one eggshell but could not assess the number of eggs or nestlings, but on 14 August there were three nestlings about 5–7 d old On 14 September one young was found dead, possibly due to a *Trichomonas* infection; the other two seemed healthy Three more pairs were regularly sighted in Lima along with other territorial single individuals during the Austral winter 2001. The sighting of an immature inside Lima during late August 2000 (J. Otero pers. comm.) suggested that in fact they were already breeding inside urban Lima city before our observations.

Finally, Beingolea found fledglings between 18 July and late September indicating about a 10 wk span of egg laying for pairs nesting at 12°S. Calculating that fledgling occurs between 11 and 12 wk after onset of eggs (Cade 1988), the earliest laying for the pair having fledglings in 18 July should have taken place during the last week of April (1993) and the latest lying during the first week of July (2001). In 2001, there were a total of six resident pairs within Lima and her outskirts.

It is generally thought that subtropical raptors regularly have smaller clutches than populations elsewhere (Newton 1979, Population ecology of raptors. Buteo Books, Vermillion, SD U.S.A.), but the Peruvian nests checked averaged 3.71 young/pair, at the high end of peregrine fledging numbers. A failed attempt, due to predation, also had four eggs, further suggesting that large clutch sizes are common.

The breeding season for Peruvian peregrines differs from those in central to southern Chile and Argentina; the latter breed in the Austral spring, but central Peruvian peregrines nest during the Austral fall and winter. Distance and different breeding seasons might restrict gene flow between these populations. Lack of gene flow and different climatic and environmental selection pressures probably explains the morphological differences. Northern birds are paler, less heavily marked on the breasts and smaller, about 800 g for northern and 950 g for southern females and about 550 g for northern males (with one at 480 g) and 650 g for southern males (O. Beingolea unpubl. data, see White 1989). Further studies on the geographic differences within South American populations are needed.

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LONE HARRIS'S HAWK KILLS GREAT BLUE HERON

The Harris's Hawk (*Parabuteo unicinctus*) is a neotropical species whose range extends into the southwest U.S., resident from southeast California (Colorado River area; irregularly), south and central Arizona, to southwest and south Texas (Bednarz 1995, *In* A. Poole and F. Gill [EDS.], The birds of North America, No. 146. The Academy of Natural Sciences, Philadelphia, PA and The American Ornithologists' Union, Washington, DC, U.S.A.). In New Mex-

ico, the species nests across the southern tier of counties and north in the Rio Grande Valley to Sierra County (S. Williams pers. comm.).

Published accounts of Harris's Hawk food habits report the majority of its prey as (in order of dominance) medium-sized to relatively large mammals (particularly rabbits and hares [Leporidae]), birds, and reptiles (Mader 1975, *Living Bird* 14:59–85; Whaley 1986, *Raptor Res.* 20:1–15; Bednarz 1988a, *Condor* 90:311–323; Bednarz 1995). Bent (1937, *Bull. U S. Natl. Mus.* 167:142–147) listed relatively large avian prey items as Common Moorhen (*Gallinula chloropus*), night-herons (*Nycticorax nycticorax, Nyctanassa violacea*), Snowy Egret (*Egretta thula*), and Green-winged Teal (*Anas crecca*); Whaley (1986) observed remains of a Cooper's Hawk (*Accipiter cooperii*) in one nest in Arizona. Here, we report our observations of an attack on a Great Blue Heron (*Ardea herodias*) by a Harris's Hawk.

At ca. 1630 H on 21 July 2000, a juvenile (less than 12 mo) Great Blue Heron waded in a puddle near our camp in the Gila National Forest Bird Habitat Area, Grant County, New Mexico. The bird did not fly as we approached to within 5 m, but slowly walked off into the young mesquite (*Prosopis glandulosa*) growth. We assumed it was in the area to feed on the abundant grasshoppers (Orthoptera). On at least two prior occasions, we had seen a Great Blue Heron roost in nearby trees. About 2 hr later, we heard a prolonged croaking cry and investigated. An immature Harris's Hawk flew off the now prostrate heron and perched ca. 50 m away. Its plumage (white in the wings and underparts) indicated that the hawk was an immature bird (Clark and Wheeler 1987, A field guide to hawks of North America, Houghton Mifflin Co., Boston, MA U.S.A.). The heron was still alive, but it died within a minute. We detected no obvious external injuries when we examined it, but no internal exam or necropsy was performed. We are uncertain why it did not fly or defend itself from apparent attack. The hawk remained perched in the tree for about 10 min before flying away. We saw the hawk later that day and on subsequent days, but it never returned to the heron carcass.

The age of the bird supports prior observations on hawk hunting behavior. Generally, immature solo hawks (particularly in falconry) exhibit more reckless and daring behavior than birds in adult plumage, often attacking inappropriately large prey (J. Bednarz and J. Coulson pers. comm.). Perhaps the Harris's Hawk's age and inexperience led it to attack the Great Blue Heron.

We believe this account to be the first recorded for Harris's Hawk predation upon a bird as large as the Great Blue Heron. The mean mass of this hawk's largest known avian prey (Common Moorhen, 334 g; Green-winged Teal, adult males, 364 g; Snowy Egret, 371 g; Cooper's Hawk, adult females, 529 g; and Black-crowned Night-heron, 883 g) is much smaller than that of the Great Blue Heron (2204–2576 g [Dunning 1993, Body weights of 686 species of North American birds. International Wildlife Rehabilitation Council, Suisun, CA U.S.A.]). A single Harris's Hawk is thus capable of attacking and killing much larger birds than previously reported.

Although the Great Blue Heron is the largest documented avian prey taken by a wild Harris's Hawk (captive Harris's Hawks flown in falconry have incidentally captured healthy Great Blue Herons [T. and J. Coulson pers. comm.]), its weight is less than that of adult female black-tailed jackrabbits (*Lepus californicus*, >3000 g) commonly taken by hunting groups (Bednarz 1988b, *Science* 239:1525–1527),and occasionally by solitary hunting Harris's Hawks (Brannon 1980, The reproductive ecology of a Texas Harris's Hawk [*Parabuteo unicinctus harrisi*] population. M.S. thesis, University of Texas, Austin, TX U.S.A.).

BOOK REVIEWS

Raptors in the New Millennium. Edited by Reuven Yosef, Michael L. Miller, and David Pepler. 2002. International Birding & Research Center, Eilat, Israel. 276 pp., numerous tables and figures. Softcover, $20.00.—This volume constitutes the proceedings of the joint meeting of the Raptor Research Foundation and the World Working Group on Birds of Prey and Owls that was held in Eilat, Israel, from 2–8 April 2000. Close to 200 biologists from 30 countries attended the meeting, which consisted of 84 oral presentations and 17 posters.

In total, the book contains 29 papers (ranging in length from 2 to 22 pages) and 80 abstracts published in English under eight subject headings: General & Techniques (2 papers, 8 abstracts), Diet and Foraging (1, 3), Reproductive Ecology (4, 12), Migration and Wintering Ecology (10, 8), Population Status and Ecology (6, 24), Genetics and Taxonomy (2, 7), Ecotoxicology and Diseases (2, 11), and Conflicts and Solutions (2, 7). As expected, the range of species studied and topics covered is quite large, although taxonomically the papers are dominated by diurnal raptors. Indeed, only four of the 29 papers are devoted to owls (two on Barn Owls [*Tyto alba*], and one each on the Little Owl [*Athene noctua*] and the Tawny Owl [*Strix aluco*]). Among the highlights in the collection is a paper on identifying "real threats" to raptor populations (Kenward), one on the breeding biology of Greater Spotted Eagles (*Aquila clanga*) in Poland (Graszynski et al.), one on modeling habitat suitability for Little Owls in Belgium (Van Nieuwenhuyse and Bekaert), one on migration routes and habitat selection by nonbreeding Lesser Kestrels (*Falco naumanni*) in Africa (Pepler), an update on the status of Great Philippine Eagles (*Pithecophaga jefferyi*) on Mindanao (Miranda et al.), and a global review of lead poisoning in falconiforms (Miller et al.).

The proceedings provide a snapshot of raptor research currently underway across a vast portion of the globe, albeit with a bias toward studies of Palearctic falconiforms. The editing is very good considering that English must not have been the first language for many of the authors. Given the range of topics and species covered, and the attractive price (which includes shipping), *Raptors in the New Millennium* will be a welcome addition to libraries—both personal and public—around the world. To obtain a copy, write the International Birding & Research Center, P.O. Box 774, Eilat 88000, Israel ⟨http://www.arava.org/birds-eilat/index.html⟩.—**Jeff Marks, Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, MT 59812 U.S.A.**

Birds of the Saskatoon Area. Edited by A.L. Leighton, J. Hay, C.S. Houston, J.F. Roy, and S. Shadick. 2002. Saskatoon Natural History Society Spec. Publ. No. 23. 345 pp., 31 color photographs, 40 line drawings, 14 maps, 8 appendices. ISBN 0-921104-19-7. Softcover, $39.00 Canadian.—This book presents a compilation of bird records for the Saskatoon Bird Area (SBA), which encompasses an 11 012-km² block centered near Moon Lake just south-southwest of Saskatoon, the largest city in Saskatchewan. The roughly 60 000 observation cards of birds submitted by hundreds of members of the Saskatoon Natural History Society between 1965 and 1988 form the basis of the book, the project being a massive undertaking by a dedicated group of individuals committed to understanding the birds of their local area. The result is a detailed picture of the timing of occurrence and status for the nearly 350 species of birds that were recorded. Introductory sections contain information on the history of the project, the physical and biological properties of the region (including some great color photos of habitat), a glossary of terms, and a brief guide to interpreting the species accounts. The eight appendices contain, among other

things, summaries of Breeding Bird Survey data for four time periods (up to 2000), summaries of banding efforts and recoveries/recaptures for the area, and a list of theses from the University of Saskatchewan that involved bird research in the SBA.

The species accounts range in length from about one-third of a page to just over two pages and focus on arrival and departure dates, status, and habitat affinities. Twenty-nine species of raptors are treated, 17 falconiforms and 12 owls. Perhaps not surprisingly, given that Stu Houston is one of the editors, the raptor accounts are among the most detailed and interesting in the book. For example, it turns out that Saskatoon is one of the best spots on the continent to observe nesting Merlins (*Falco columbarius*). In excess of 30 pairs breed within the city limits in some years, and more than 2000 individuals, mostly nestlings, have been banded there. At the nocturnal end of the spectrum, Great Horned Owls (*Bubo virginianus*) have also received a lot of attention. The species account reports that 1208 nestlings from 401 nests were banded in the SBA between 1961 and 1998. To date, 130 have been recovered or recaptured, 118 in the SBA and

the remainder in Alberta, Manitoba, Iowa, Minnesota, Montana, North Dakota, and South Dakota. On balance, each account contains an interesting tidbit or two, including some valuable natural history information, on the bird's presence in the SBA.

I must admit that when *Birds of the Saskatoon Area* arrived, I hesitated to review it for JRR because raptors were not its focus. However, as I flipped through the pages, and especially after I read the introductory portions, I realized the importance of drawing attention to a work of this sort. The publication represents the collective efforts of a group of people who are truly engaged in the natural history that surrounds them. So engaged, in fact, that hundreds of them cooperated to gather the information and make it available to the entire community. Imagine how wonderful it would be if all other cities the size of Saskatoon or larger had among their citizenry a group of people similarly engaged in nature and suitably motivated to compile bird records and produce so useful a publication.—**Jeff Marks, Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, MT 59812 U.S.A.**

Manuscript Referees

The following people reviewed manuscripts for the *Journal of Raptor Research* in 2002. Peer review plays a vital role in the publishing process and in improving the quality of the Journal. The editorial staff would like to thank the following for reviewing manuscripts this past year. The names of those who reviewed two or more manuscripts are indicated with an asterisk.

L. Alterman, D. Andersen, R. Antor, L. Arent, D. Arsenault, J. Balbontín-Arenas, T. Balgooyen, W. Baltosser, M. Bechard, J. Bednarz*, I. Bellocq*, J. Berkelman, K. Bildstein, R. Bierregaard, D. Bird, P. Bloom*, T. Bloxton, G. Boano, P. Bohall Wood, T. Bosakowski, R. Bowman, P. Boxall, R. Bradley, U. Brendel, T. Brush, J. Buchanan, D Buehler, T. Cade*, J. Cartron, J. Cerdá, J. Chantler, S. Chaplin, H. Chen, A. Clarke, N. Clum, M. Collopy, C. Conway, S. Debus, M. Desmond*, S. DeStefano, S. Deem, D. Dekker*, M. de Lucas, L. Dickson, J. Donázar*, C. Dove, F. Doyle, J. Duncan*, C. Dykstra, J. Elliott, D. Ellis, J. Enderson*, P.L. Enriquez, D. Evans, S. Fattorini, M. Ferrer*, L. Forbes, M. Forero, E. Forsman, G. Foster*, A. Fowler, J. Fraser*, T. French, R. Frumkin, M. Fuller, V. Galushin, L. Gangoso, H. Garner*, R. Garrott, F. Gehlbach, J. Gehring*, S. Gillihan, R. Glinski, M. Goldstein, T. Grubb*, R. Gutierrez, H. Hakkarainen, P. Hall, A. Harmata*, R. Harper, G. Hayward, C. Henny*, L. Hillstrom, S. Holman, G. Holroyd*, D Holt*, T. Huels, G. Hunt*, E. Inigo-Elias, J. Jackson, F. Jaksic*, S. Janes, A. Jenkins, J. Jimenez, R. Jovani, T. Katzner, R. Kavanaugh, P. Kerlinger, T. Kimmel, M. Kochert*, E. Korpimäki, P. Koskimies, W. LaHaye, R. Lehman, G. Leonardi, K. Levenstein, J. Lish, M. Louette, A. Lueders, T. Maechtle, L. Marchesi, B. Marcot, S. Markman, J. Marks*, M. Martell*, C. Marti*, J. Marzluff*, W. Mattox, M. McGrady, D. McLeod*, M. McMillian*, E. McNabb, S. Melvin, B. Millsap*, J. Mitani, C. Moorman, M. Morrison*, P. Mundy, R. Murphy, W. Nelson*, R. Nero*, P. Nye, C. Olson, J Orr, J. Pagel, M. Patten, E. Pavez*, V. Penteriani*, M. Perry, J. Plissner, A. Poole, C. Preston*, G. Proudfoot*, J. Rau, P. Redig, E. Revilla, R. Reynolds, S. Rinkevich, D. Ripper*, G. Ritchison*, A. Rodriguez, R. Rodríguez-Estrella, R. Rosenfield, L. Salvati*, J. Sanchez-Zapata*, B. Sandercock, J. Schmutz, L. Schueck, M. Seamans, J. Seoane, F. Sergio*, J. Shelnutt, S. Shiraki, J. Sikarskie*, J. Smallwood, R. Smith*, R. Spaar*, B. Spears, J. Squires*, D. Stahlecker*, M. Stalmaster, T. Swem*, S. Talbot, J.M. Thiollay*, P. Thomas, W. Thompson*, D. Tinkler, K. Titus, F. Tseng*, J. Valkama, S. Vanderwall, J. Vargas, D. Varland*, A. Village*, J. Ward, I. Warkentin*, P. Weatherhead, D. Whitacre*, C. Williams, W. Whaley, C. White*, K. Wiebe, S. Wiemeyer, C. Wightman, J. Withey, B. Woodbridge, S. Xirouchakis, R. Yates, S Zack, Z. Zhenwang.

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The Raptor Almanac: A Comprehensive Guide to Eagles, Hawks, Falcons, and Vultures. Scott Weidensaul. Lyons Press, 2000. 382 pp. Color photos. Cloth. $40.00

The Harris Hawk: Management, Training and Hunting. Lee W. Harris. Swan Hill Press, 2001. 144 pp. Color and b&w photos and illustrations. Cloth. $32.95

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The **Fran and Frederick Hamerstrom Award** recognizes an individual who has contributed significantly to the understanding of raptor ecology and natural history. Nomination packets can be submitted at any time. Contact: **Dr. Clint Boal**, Texas Cooperative Fish and Wildlife Research Unit, BRD/USGS, Texas Tech University, 15th Street & Boston, Ag Science Bldg., Room 218, Lubbock TX 79409-2120 U.S.A.; tel. (806) 742-2851; e-mail: cboal@ttacs.ttu.edu.

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The **James R. Koplin Travel Award** is given to a student who is the senior author and presenter of a paper or poster to be presented at the RRF annual meeting for which travel funds are requested. Contact: **Dr. Patricia A. Hall**, 5937 E. Abbey Rd. Flagstaff, AZ 86004 U.S.A.; tel. 520-526-6222; e-mail: pah@spruce.for.nau.edu. Application Deadline: due date for meeting abstract.

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Grants

For each of the following grants, complete applications must be submitted to the contact person indicated by **15 February**. Recipients will be notified by 15 April.

The **Dean Amadon Grant** for $200–400 is designed to assist persons working in the area of distribution and systematics (taxonomy) of raptors. Contact: **Dr. Carole Griffiths**, 251 Martling Ave., Tarrytown, NY 10591 U.S.A.; tel. 914-631-2911; e-mail: cgriff@liu.edu.

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